APR 27 1896 LIBRARY

On the Derivation of X Rays

The JOURNAL OF ELECTRICITY

AN ILLUSTRATED REVIEW OF THE INDUSTRIAL APPLICATIONS OF ELECTRICITY, GAS AND POWER.

VOL., II, No. 3 SAN FRANCISCO, MARCH, 1896. { YEARLY SUBSCRIPTION, $1.00 / SINGLE COPIES, - - 10 cents

TABLE OF CONTENTS

PHYSICS:— Page.
On the Derivation of X Rays (Illustrated)
Part I—Cathode Radiation, by Prof. Fernando Sanford 51
Part II—Anode Radiation, by Philip Mills Jones, M. D. 55
Part III—Deductions from Dr. Jones' Experiments, by Prof. Fernando Sanford 61
The Determination of a Light Unit (Illustrated), by D. W. Murphy 61
HYDRAULICS:—
An Experience in Flume Construction (Illustrated) 69

EDITORIAL:— Page.
Standard Wiring Rules 66
Now or Never 66
The Use and Abuse of Fuses 67
Accurate Photometric Measurements 67
The Patent Situation 68
PASSING COMMENT:—
The Deficiencies of American Arc Lighting Systems 64
The Influences of Attractiveness on Station Economy 64
An Unwarranted Condemnation 65
Testing Arc Lighting Circuits 65

THE TRADE:— Page.
Protection Against Lightning (Illustrated) 70
New Railway Supply Agencies (Illustrated) 72
THE LAY PRESS:—
Popular Reflections, Etc. 73
PERSONAL 74
OBITUARY 74
REPORTS OF THE MONTH:—
Litigation 75
Transportation 75
Incorporation 76
Transmission 76
Illumination 77

THE WESTON STANDARD

THE WESTON AMMETER.

PORTABLE
VOLTMETERS, AMMETERS and WATTMETERS

Send for New Catalogue.

WESTON ELECTRICAL INSTRUMENT CO.
114-120 WILLIAM ST., NEWARK, N. J.

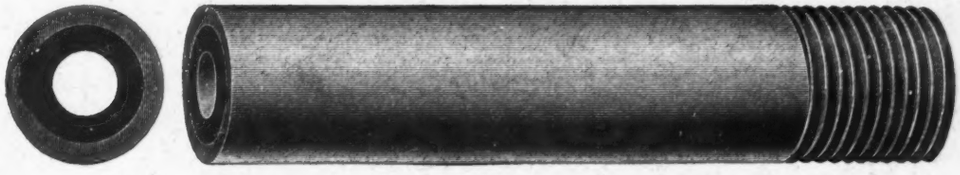
INSULATED WIRES AND CABLES
OF SUPERIOR QUALITY

OKONITE
TRADE MARK.

THE OKONITE CO., LTD.
WILLARD L. CANDEE, H. DURANT CHEEVER } Managers.
GEO. T. MANSON, Gen'l Supt.
W. H. HODGINS, Sec'y.
13 PARK ROW, NEW YORK

INSULATING CONDUIT
LUNDELL ✦ FAN ✦ AND ✦ POWER ✦ MOTORS

BRASS and IRON ARMORED



Two Wires in one Iron Armored Tube

The Standard Method OF INTERIOR WIRING

Interior Conduit and Insulation Company
527-534 WEST THIRTY-FOURTH STREET
NEW YORK

RISDON IRON WORKS

CABLE ADDRESS: "RISDON"

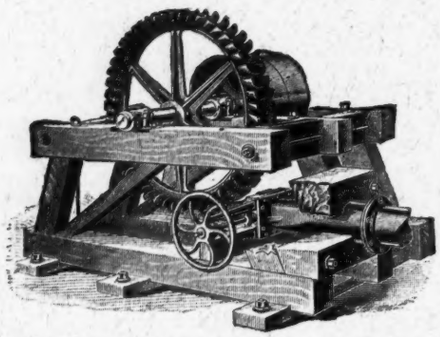
SAN FRANCISCO, CALIFORNIA

AGENTS FOR THE KNIGHT WATER WHEEL

MANUFACTURERS OF

ELECTRIC LIGHTING PLANTS

BALL ENGINES



The above cut shows the general arrangement of one of Knight's Standard Water Wheels, of which there are more than 450 in use in California alone. These wheels are made from 2 feet to 6 feet in diameter, from 10 to 1000 horse power, and adapted to all heads and purposes.

Descriptive circulars mailed free on application.

—BUILDERS OF—

ELECTRIC RAILWAY and POWER PLANTS

HEINE BOILERS

Mining, Milling, Hoisting and Pumping Plants

STEAM, WATER OR ELECTRIC POWER

Soft Bare Copper Wire.

Insulated Feeder Wire.

Heavy Stranded Feeder Conductors.

Lead Covered Underground Cables.

Rubber Insulated Wire.

Span Wire, Bare and Insulated.

Magnet Wire for Armature Repairs.

Iron and Steel Telegraph Wire.

Hard Drawn Copper Telephone Wire.

Copper Rods for Station Work.

"Crescent" Rubber Covered Wire

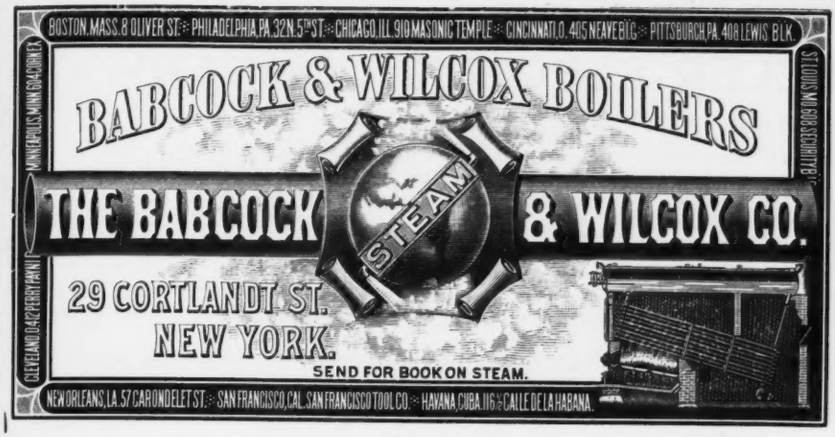
ORDERS EXECUTED PROMPTLY.

Large Stock on Hand.

HARD COPPER AND SILICON BRONZE TROLLEY WIRE.

Correspondence Solicited as per Address in Wire Rope Circle.

Chas. C. Moore, Pacific Coast Agent, - 32 First St., S. F.


BOSTON, MASS. 8 OLIVER ST. ✻ PHILADELPHIA, PA. 32 N. 5TH ST. ✻ CHICAGO, ILL. 910 MASONIC TEMPLE ✻ CINCINNATI, O. 405 NEAVE BLG. ✻ PITTSBURGH, PA. 408 LEWIS BLK.
MINNEAPOLIS, MINN. 604 GARDNER
ST. LOUIS, MO. 608 SECURITY BLG.
BABCOCK & WILCOX BOILERS
THE BABCOCK & WILCOX CO.
STEAM
29 CORTLANDT ST. NEW YORK.
SEND FOR BOOK ON STEAM.
CLEVELAND, O. 42 PEERY PANY
NEW ORLEANS, LA. 57 CARONDELET ST. ✻ SAN FRANCISCO, CAL. SAN FRANCISCO TOOL CO. ✻ HAVANA, CUBA. 116 ✻ CALLE DE LA HABANA.

ADVERTISERS' INDEX.

	PAGE
Abner Doble Co	iv
Askin & Co., H.	vii
American Circular Loom Co.	ix
American Carbon Co.	x
Babcock & Wilcox	iii
Bolton & Strong	v
Boudreaux Dynamo Brush Co.	vi
Brooks & Co., J. W.	vi, vii, viii, ix, x, xiii
Charles C. Moore & Co.	iii
California Electrical Works.	xiv
Card Electric Motor & Dynamo Co.	xx
Cobb, M. E., Edward S.	v
Cook Belting Co., H. N.	viii
Electricity Newspaper Co.	iii
Electric Insulating Co.	vii
Electrical Construct'n & Repair Co.	xiii
Electrical Engineering Co.	xvii
For Sale Advertisements	iii
Fort Wayne Electric Corporation.	xviii
Grothwell, A.	xvii
Gamewell Fire Alarm Telegraph Co.	xi
Girard Water Wheel Co.	v
Gotterke & Low.	xi
Helois Electric Company.	xiv
Interior Conduit & Insulation Co.	i
Johns Manufacturing Co., H. W.	xvii
Kaufman, C. B. & Co.	vii, viii, ix
Klein's Electrical Works, John M.	xi
Lamont, G. E.	xiii
Leffel & Co., The James	v
Martin, John	xv
Mica Insulator Co.	viii
Munsell & Co., Eugene.	vii
N. Y. Insulated Wire Co., The	xiii
Okonite Company, Ltd., The.	i
Pariser, James A.	ix
Paraffine Paint Company, The	ix
Pelton Water Wheel Co., The	vii
Reger & Atwater.	xix
Reisinger, Hugo	xi
Risdon Iron Works	ii
Roebling's Sons Company, The J. A.	ii
Simonds Manufacturing Co.	ix
San Francisco Typewriting Ex'ge.	xvii
Sprout, E. E. Sydney	iv
Stanley Electrical Manufacturing Co.	xv
Stuart Smith, E. E., M. E., W.	iv
Sterling Electric Supply Co., The.	vi
Van der Naillen School of Electricity.	v
Wagner Electric Manufacturing Co.	xiv
Want Advertisements	iii
Washburn & Moen M'f'g. Co., The.	xix
Wass, D. D.	xi
Westinghouse Electric and Manufacturing Co.	xvi
Weston Electrical Instrument Co., The	i
Woodward & Co.	viii

A FREE
ELECTRICAL EDUCATION

at Home, is at the command of every Bright Young Man who is willing to take up a pleasant line of work during his spare hours.

Send for a Pampblet of Particulars and a Sample Copy of

ELECTRICITY

a weekly illustrated journal, devoted to the popular, non-technical, yet scientifically accurate, dissemination of trustworthy information upon all electrical subjects. Both free.

Address,

ELECTRICITY NEWSPAPER CO., Publishers,
6 Park Place, New York City.

FOR SALE.

Incandescent Supplies.

1,000, 16-c. p. Thomson-Houston Colored Incandescent Lamps, in assorted colors.

3,000, 112 and 114-volt Thomson-Houston Incandescent Lamps, nearly new. The use of these lamps was discontinued because of changing to higher candle-power lamps.

5,000, Thomson-Houston Lamp Bases with platinum, intact.

25, Slattery Alternating Current Ammeters, Wood Base, Switchboard type. Scale: 0th 65 amperes.

20, Double pole, Double Throw Rocker Switches, Wood bases. Capacity: 75 amperes.

40, Single pole, Double Throw Rocker Switches, Wood Bases. Capacity: 75 amperes.

1, White Italian Marble Switchboard, 9 x 11 feet, in six Panels and drilled for 12 Incandescent Circuits, including Meter Openings. Complete with Buss Bars, Angle Iron Bracings, etc. Perfectly New and never even completely set up.

The above materials are in San Francisco and may be examined upon application. Any reasonable offer considered for entire lot or any portion of it. Address:

"M. L. W."
Care "Journal of Electricity."

FOR SALE

ONE WESTON ALTERNATING AND DIRECT Current, Direct Reading

WATTMETER

Scale 0 to 30,000 Watts; 0 to 200 amperes and 0 to 510 volts. Complete, with conducting cable and portable case. But little used and in strictly first-class condition. A bargain for cash. May be examined at the office of THE JOURNAL OF ELECTRICITY

SITUATIONS WANTED

BY AN EXPERIENCED ELECTRICIAN AND steam engineer, thoroughly familiar with the management and operation of steam, electric light and storage battery plants, gas, gasoline and coal oil engines, to take charge of central station or isolated plant, in San Francisco preferred. Long experience and the best of references.
Address: "Situation," care the Journal of Electricity.

BOOKS

on Electrical Subjects mailed to any address, POSTAGE PAID, on receipt of price.

Address

The Journal of Electricity
SAN FRANCISCO, CAL.

WALKER COMPANY

Railway Motors and Generators

CROCKER-WHEELER ELECTRIC COMPANY

Stationary Motors, Dynamos and Dynamotors.

DORNER & DUTTON M'F'G COMPANY

Car Trucks, Gears, Pinions, Wheels and Axles

BILLINGS & SPENCER COMPANY

Drop Forged Commutator Bars and Trolley Line Material.

MORRIS, TASKER & COMPANY

Electric Railway Poles, Brackets and Fittings

PHOENIX CARBON M'F'G COMPANY

GARTON-DANIELS ELECTRIC COMPANY

Lightning Arresters for all Circuits

CUTLER-HAMMER M'F'G COMPANY

Rhoestats and Motor Controllers

GENERAL INCANDESCENT ARC LAMP COMPANY

A. L. IDE & SONS

Ideal Engine s

THOS. FIRTH & SONS, Ltd.

Crucible Cast Tool Steel.

OHIO STORAGE BATTERY COMPANY

MIDVALE STEEL COMPANY

HAVE THEIR PACIFIC COAST OFFICES

. . . AT . . .

13 and 15 Fremont St., San Francisco, Cal.

ABNER DOBLE COMPANY

MANAGERS

BUYERS' DIRECTORY.

ARC LAMPS
Abner Doble Co.
J. W. Brooks & Co.
Fort Wayne Electric Corporation
Helios Electric Co. of Philadelphia
Sterling Electric Supply Co.
Westinghouse Electric and Mfg. Co.
Woodward & Co.

ASBESTOS GOODS
H. W. Johns Manufacturing Co.

BELTING
H. N. Cook Belting Co.

BOOKS AND PUBLICATIONS
Jas. A. Parisher
The Journal of Electricity
Electricity Newspaper Co.

BRUSHES
C. B. Kaufman & Co.
D. D. Wass
J. W. Brooks & Co.
Reger & Atwater

CARBONS
Hugo Reisinger
J. W. Brooks & Co.

CAR REGISTERS
C. B. Kaufman & Co.
J. W. Brooks & Co
Reger & Atwater

CONSTRUCTING ENGINEERS
Abner Doble Co.
Electrical Construction and Repair Co.
Fort Wayne Electric Corporation
John M. Klein's Electrical Works
John Martin

DISPLAY WORK
H. Askin & Co.
Electrical Construction and Repair Co.

DYNAMOS AND MOTORS
Abner Doble Co.
California Electrical Works.
Card Electric Motor and Dynamo Co.
D. D. Wass
Electrical Engineering Co.
Fort Wayne Electric Corporation
Interior Conduit and Insulation Co.
John Martin
John M. Klein's Electrical Works
J. W. Brooks & Co.
Westinghouse Electric and Mfg Co.

EDUCATIONAL
Van der Naillen's School of Electricity

ELECTRICAL ENGINEERS
W. Stuart Smith & Sidney Sprout
D. D. Wass

ELECTRICAL REPAIRING
H. Askin & Co.
California Electrical Works
Gotterke & Low
D. D. Wass
John M. Klein's Electrical Works

ELECTRICAL SUPPLIES
California Electrical Works
D. D. Wass
Gotterke & Low
John M. Klein's Electrical Works
J. W. Brooks & Co.
Sterling Electric Supply Co.
Westinghouse Electric and Mfg Co.

ENGRAVERS
Bolton & Strong

FAN MOTORS
Abner Doble Co.
California Electrical Works
Fort Wayne Electric Corporation
Interior Conduit and Insulation Co.
John M. Klein's Electrical Works
J. W. Brooks & Co.
Westinghouse Electric and Mfg Co.

FIRE ALARM TELEGRAPH
The Gamewell Fire Alarm Telegraph

GLASS BLOWERS
G. E. Lamont

INSULATED WIRES
(See Wires and Cables)

INCANDESCENT LAMPS
California Electrical Works
G. E. Lamont
John M. Klein's Electrical Works
J. W. Brooks & Co.
Westinghouse Electric and Mfg. Co.

INSTRUMENTS
California Electrical Works
Weston Electrical Instrument Co.

INSULATING COMPOUND
J. W. Brooks & Co.
Electric Insulating Co.
C. B. Kaufman & Co.
A. Grothwel:
New York Insulated Wire Co.
Paraffine Paint Co.

INTERIOR CONDUIT
American Circular Loom Co.
Interior Conduit and Insulation Co.

LINE MATERIALS
(See Electrical Supplies).

MARINE SUPPLIES
D. D. Wass

MECHANICAL ENGINEERS
Edward S. Cobb
W. Stuart Smith & Sidney Sprout

MICA GOODS
C. B. Kaufman & Co.
H. W. Johns Manufacturing Co.
J. W. Brooks & Co.
Reger & Atwater

MINING APPARATUS
Abner Doble Co.
J. W. Brooks & Co.
Electrical Engineering Co.
Fort Wayne Electric Corporation
John Martin
Risdon Iron Works
Westinghouse Electric and Mfg Co.

POWER TRANSMISSION
Abner Doble Co.
J. W. Brooks & Co.
Electrical Engineering Co.
Fort Wayne Electrical Corporation
John Martin
Risdon Iron Works
Westinghouse Electric and Mfg. Co.

RAILWAY SUPPLIES
Abner Doble Co.
C. B. Kaufman & Do.
J. W. Brooks & Co.
Reger & Atwater
Simonds Manufacturing Co.

STEAM BOILERS
Risdon Iron Works
The Babcock & Wilcox Co.

STEAM ENGINES
Risdon Iron Works

TELEPHONES
California Electrical Works
John M. Klein's Electrical Works

TRANSFORMERS
Fort Wayne Electrical Corporation
John Martin
Wagner Electric and Manufacturing Co
Westinghouse Electric and Mfg. Co.

TYPEWRITING SUPPLIES
Leo E. Alexander & Bro.
San Francisco Typewriting Exchange

WATER WHEELS
Girard Water Wheel Co.
Jas. Leffel & Co.
Risdon Iron Works
The Pelton Water Wheel Co.

WIRES AND CABLES
J. W. Brooks & Co.
California Electrical Works
John A. Roebling's Sons Co.
New York Insulated Wire Co.
Sterling Electric Supply Co.
The Okonite Co.
Washburn & Moen Manufacturing Co.

SAMSON AND CASCADE

WATER WHEELS

ADAPTED TO ALL HEADS FROM

3 FEET TO 2000 FEET.

Specially designed and adapted to

ELECTRIC POWER AND LIGHTING PLANTS.

Securing a **high guaranteed percentage** and **great steadiness** of motion under variable loads. An **unequaled concentration** of power, and an **unprecedented high velocity.** Its **quickly operating balanced gates,** affords **prompt** and **fine regulation** by governor. **Satisfaction guaranteed where others fail.**

Write for pamphlet of either, stating your wants.

JAMES LEFFEL & CO., Springfield, Ohio, U.S.A.

NEW ADVERTISEMENTS.

GIRARD WATER WHEEL.

34 MAIN ST. SAN FRANCISCO, CAL.

Send for Catalogue.

SCHOOL OF

Practical Electrical,

Civil, Mining and Mechanical Engineering, Surveying, Drawing, Architecture and Assaying

No. 723 Market Street

SAN FRANCISCO

ESTABLISHED 1864

A. VAN DER NAILLEN,

Send for Circulars — **President**

BOLTON & STRONG

Printing Plate Manufacturers

HALF-TONES A SPECIALTY

510-512-514 Montgomery St.

SAN FRANCISCO.

PROFESSIONAL

W. Stuart-Smith & Sidney Sprout

Consulting and Supervising

Mechanical and Electrical Engineers

Electric Lighting and Power Plants Designed. Steam and Electrical Machinery Carefully Tested.

Electro-Economics and the Electric Transmission of Power a Specialty

422 Safe Deposit B'ld'g

Telephone, Main 5700 — San Francisco

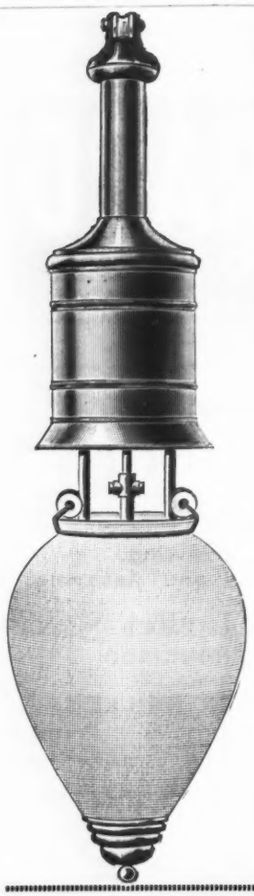
EDWARD S. COBB

MECHANICAL ENGINEER

109 California or 23 Davis St.,

Telephone "Red 55" — Rooms 30-31

San Francisco. Cal.



THE STERLING ELECTRIC SUPPLY CO.

18 Second Street, San Francisco

PACIFIC COAST AGENTS FOR THE

Standard Thermometer and Electric Co.

MAKERS OF THE CELEBRATED

UPTON ARC LAMPS FOR ALL CIRCUITS

The Emerson Electric Manufacturing Company, Alternating Current Motors and Transformers

WE ALSO HANDLE THE APPARATUS OF THE

Fort Wayne Electric Corporation

For Arc, Incandescent and Transmission Purposes.

Bare, Weatherproof, Magnet and Annunciator Wire, Lamps, Cords, Etc.

Estimates cheerfully furnished for everything electrical.

Sinew and Acme Insulating Tapes

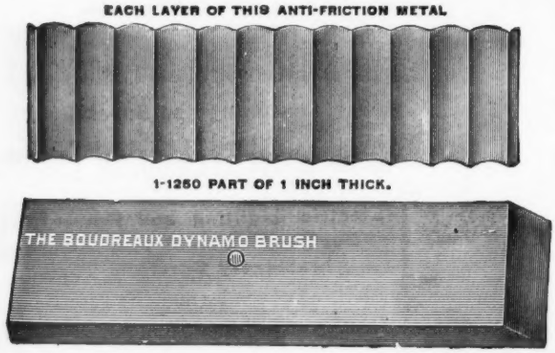
When in need of

WIRE SOLDER, BAR SOLDER, SOLDERING SALTS, SOLDERING STICKS, BLOW TORCHES, ETC., write to us . . . .

We are headquarters for all such materials and it will pay you.

J. W. **BROOKS** & Co.

San Francisco, Cal.



WE DO NOT SELL A COMMUTATOR COMPOUND for the reason that the Boudreaux Dynamo Brushes **DO NOT REQUIRE IT.** They run perfectly cool, without sparking, and do not cut the commutator.

YOU HAD BETTER TRY THEM

J. W. Brooks & Co.
Sales Agents,
SAN FRANCISCO, CAL.

THE BOUDREAUX DYNAMO BRUSH CO.

ORDER **"STANDARD WIRING FOR ELECTRIC LIGHT AND POWER"**

By H. C. CUSHING, Jr., Electrical Inspector B. B. F. U.
ADOPTED BY THE FIRE UNDERWRITERS OF THE UNITED STATES

Russian Leather Cover
Pocket Size, Price, $1.00

IT contains every table, formula and rule for all systems of outside and inside wiring, together with twenty-five illustrations of the newest and safest methods for the installation of Pole Lines, Dynamos, Motors, Switchboards, Transformers, etc., etc., as required by the insurance inspector.

By Mail Post Paid on Receipt of Price by THE JOURNAL OF ELECTRICITY, 328 Montgomery St.

The Electric Insulating Co.

(Successors to Hennig & Kuhlau Compound Co.)

Manufacturers of the Peerless Armature Compound

2720 Market Street, St. Louis

In winding Armatures, Fields Fuse Boxes, etc., it is indespensible. Nothing equals it for commutators. Absolutely Fire and Water Proof. The longer in service the more resistance it offers. Send for sample. Put up in one, two, three, five and ten gallon, half and barrel packages. Full stock kept with

'Phone Main 616 C. B. Kaufman Co., 525 Mission St., S. F.

MICA, INDIA AND AMBER

Stamped MICA Segments and Solid Sheet MICA Segments gauged to thickness for all the Standard Street Railway Motors.
MICA Washers, MICA in the Sheet, and cut to any size and pattern.

EUGENE MUNSELL & CO., Importers direct from the mines.

J. W. BROOKS & CO., SALES AGENTS

523 Mission Street, San Francisco

THE FEATURES
THAT PLEASE
IN OUR

Repair Department

are PROMPTNESS
UNEXCELLED WORKMANSHIP
LOWEST COST

Dynamos and Motors—Both New and Second-hand—
Manufactured and in Stock

ARMATURES
FIELD COILS
ARC LAMPS
Rewound or Repaired

ALL WORK GUARANTEED

H. ASKIN & CO.

27 Stevenson Street

Write for Prices San Francisco

THE PELTON SYSTEM OF POWER
Represents the highest development yet attained in water wheel practice and affords the most simple, efficient and economical means of utilizing water for power purposes.

SIX THOUSAND WHEELS NOW RUNNING,
Aggregating over 400,000 horse power. Adaption made to all conditions and every variety of service.

ELECTRIC POWER TRANSMISSION.
PELTON WHEELS are the recognized standard for electrical work and are running a majority of the stations of this character in all parts of the world.

Catalogues furnished upon application. Address

THE PELTON WATER WHEEL CO. 143 Liberty St., New York 121 Main St., San Francisco, Cal.

Micanite, THE STANDARD INSULATION.

PERFECT MICANITE INSULATOR REGISTERED

MICANITE plates 18x36 inches, any desired thickness. MICANITE and EMPIRE Cloth and paper in rolls 16 feet by 32 inches, and in sheets.

We Carry Stock and can immediately ship commutator segments, rings and slot insulation for all types of railway motors and many of the standard makes of power generators.

We Manufacture and can promptly execute the orders for MICANITE tubes, discs, caps, commutator rings, segments and special forms of insulation for any system of electrical apparatus.

Write for catalogue and prices

MICA INSULATOR CO.,
Sole Manufacturers

J. W. BROOKS & CO., Sales Agents.
523 Mission St., San Francisco, Cal.

UPTON ARC LAMPS FOR ALL CIRCUITS

CHEAPEST TO BUY, USE AND MAINTAIN

Non-Synchronous
Single Phase
Power Motors

Protect your Station and Cars with Automatic **Circuit Breakers**

WOODWARD & CO. 26 Luning Building San Francisco, Cal.

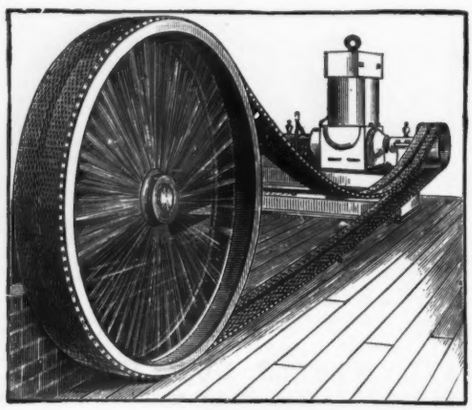
General Railway Supplies

WE carry in stock every requirement for your current supplies. We handle nothing but the best articles manufactured, and stand by our goods as we represent them. . .

Send for Prices, and hurry along your requisitions

'PHONE. MAIN 616

C. B. Kaufman & Co.
525 Mission Street
SAN FRANCISCO



ESTABLISHED 1860

H. N. COOK BELTING CO.

Tanners and Manufactures of

PURE OAK-TANNED

LEATHER BELTING

Patent Differentially Stretched
Cook & Houston, Patentees, 1895.

OFFICE AND BELT FACTORY

317-319 Mission St., San Francisco.

L. J. SCOOFEY, Eastern Agent, 304 Broadway, New York

EVERY ELECTRICIAN KNOWS IT USES IT APPROVES OF IT

Armature Varnish

ELECTRICAL COMPOUND

INSULATING TAPE

MANUFACTURED ONLY BY **PARAFFINE PAINT CO.**

116 Battery Street, San Francisco, Cal
111 So. Broadway, Los Angeles, Cal.

Electro-Chemistry of the Storage Cell

. . . BY . . .

ARTHUR HOUGH, A. I. E. E., F. C. S., London

An exhaustive treatise of the Theory and Practical Applications of Electrical Accumulators.

Price, $2.50

About 300 pages
8-vo. cloth
Illustrated

JAMES A. PARISHER, Publisher
523 Market St., San Francisco

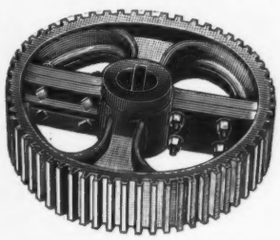
FLEXIBLE CONDUIT

AMERICAN CIRCULAR LOOM CO. TRADE MARK. FLEXIBLE CONDUIT

J. W. BROOKS & CO.

523 Mission Street, - - San Francisco, Cal.

THE SIMONDS MANUFACTURING COMPANY



Electric Railway Supplies

PITTSBURG, PA.

Our Crucible Steel Gears and Pinions

Are of Unsurpassed Quality

A Full Stock for Immediate Delivery kept by

C. B. KAUFMAN & CO.

'Phone Main 616

525 Mission Street, San Francisco

CARBONS

THE

AMERICAN CARBON CO.

IS FIGHTING THE TRUST

It Will PAY YOU to
Write for Prices, Etc.

J. W. BROOKS & CO.
(SALES AGENTS)
523 Mission Strcet San Francisco, Cal.

The Journal of Electricity

VOL. II. MARCH 1896. No. 3

On the Derivation of X Rays

Part i

CATHODE RADIATION.

BY FERNANDO SANFORD,
Professor of Physics, Leland Stanford Junior University.

The phenomena accompanying the electric discharge through rarified gases have furnished an attractive field for physical investigation ever since they were systematically studied by Faraday in 1838 and since 1891, the attention of physicists has been more than ever attracted to these phenomena by the

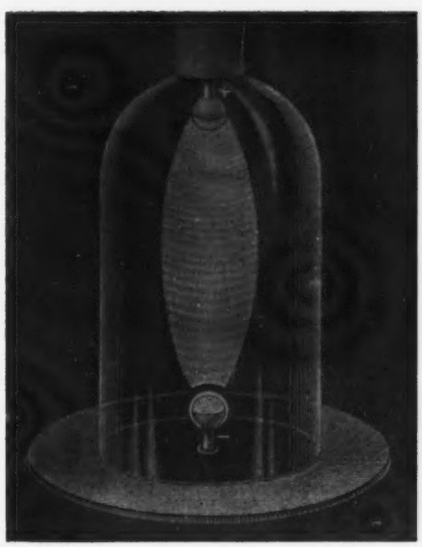


FIGURE 1—Discharge in a globe exhausted to 4 millimeters of mercury showing the stratified glow of positive light.

brilliant discoveries of Hertz and his pupil Lenard. A brief description of the different forms of electrical discharge through gases may be given somewhat as follows:

If a glass tube provided with sealed in, platinum electrodes and a stopcock for exhausting the air, have its electrodes connected to the discharging knobs of an electric machine or the secondary terminals of an induction coil while the stopcock is connected with an air pump, and if sparks be passed between the electrodes while the air is being exhausted, no change from the ordinary spark discharge will be observed until the pressure within the tube has been reduced to about 250 mm. of mercury. At about this pressure the spark discharge will be accompanied by a brush discharge, such as may be observed about a pointed conductor attached to one of the knobs of an electric

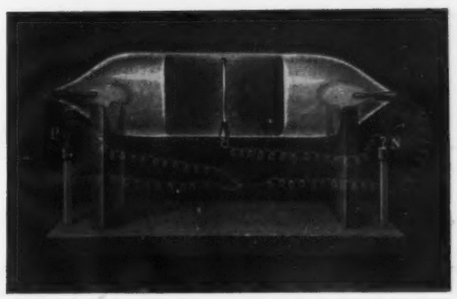


FIGURE 2—Discharge in a highly exhausted tube, showing positive light at the ends and negative glow in the center, gradually shading into the dark cathode space between the negative and positive glows.

machine. In the exhausted tube, this brush discharge will be seen only about the positive electrode. When the pressure in the tube has been reduced to about 150 mm. of mercury, the spark discharge will cease entirely, and the brush discharge from the positive electrode will take more and more the appearance of a reddish glow, and is known as the "Positive Light." This positive light spreads out more and more as the pressure in the tube is decreased, until at about 4 mm. pressure it will fill the whole tube and extend across to the negative electrode. As the pressure is still further decreased, the light appears stratified, and the interior of the tube becomes filled with alternate dark and light layers reaching across the tube perpendicular to the line of discharge. The more the pressure is diminished, the farther these layers become separated from each other.

The above can be regarded as only a very general

FIGURE 3—Highly exhausted tube for showing the rotation of a light paddle wheel under the influence of the cathode discharge.

description of the phenomena of the positive light, since the size and shape of the tube and the form and relative position of the electrodes have been found

Copyright 1896. By Geo. P. Low. All Rights Reserved.

to influence materially the appearance of the discharge. For example, the spark discharge may take place between ball electrodes at a pressure as low as 20 mm. of mercury.

The stratification spoken of is the condition usually observed in the so-called Geissler's tubes. If an induction coil or an electric machine be used to produce the effect, the positions of the dark and light strata are unsteady, and are more unsteady the farther apart and the fainter they are. If the electro-motive force be produced by a battery or constant current genera tor, they remain fixed in position. They are supposed to exist in all kinds of rarified gases, except, perhaps,

FIGURE 4—Highly exhausted tube in which the cathode discharge is shown bent under the influence of a magnet while the positive light proceeds undisturbed to the broken end of the tube.

mercury vapor. The color of the stratified positive light is, however, different in different gases. In air it is of a reddish orange color.

If the discharge be taking place through rarified air, while the tube is yet filled with the reddish, stratified positive light, a bluish glow may be seen around the negative electrode. As soon as the pressure has fallen to about 2 mm. this reddish blue or violet glow spreads rapidly from the negative electrode (called the cathode) and is separated from the positive light by a so-called dark space in which, if the other light be screened from the eye, a faint, pale blue light may be seen. The reddish blue light is known as the cathode glow, and the darker space around it as the cathode space.

As the vacuum becomes more and more perfect, the cathode glow increases rapidly in size and pushes its darker mantle farther and farther along the tube, while the positive light recedes more and more toward the anode. Finally, when the extreme limit of exhaustion with an ordinary mercury pump is reached, a pencil of pale blue rays is seen to start from the cathode, pass through the cathode glow and the cathode space, and impinge upon the walls of the tube, or upon the anode. These pale blue rays are called the Cathode Rays. At the time when they become plainly visible in the tube, the positive light has either disappeared, or is confined to a small space about the anode, and the tube becomes practically filled with the reddish blue cathode glow and the pale blue cathode rays.

The cathode rays, on account of their peculiar properties, have recently attracted more attention than the other kinds of light in the tube. Some of the properties of these rays may be briefly mentioned.

The first thing to strike the attention of the observer is the fact that they seem to go out in straight lines in all directions perpendicular to the surface of the cathode, and seem to be but little influenced in their direction by the position of the positive electrode. In fact they may be made to go off through the tube in a direction opposite to the anode. On account of their leaving the cathode perpendicular to its surface, they will form a beam of parallel rays if the cathode surface be a plane, or they will converge to a focus and diverge after passing through this focus, if the cathode surface have the form of a concave mirror. They usually carry with them small metallic particles from the cathode which are deposited upon the glass and form a metallic mirror where the rays impinge upon it. It has been found that aluminum is less volatilized by the cathode discharge than other metals, and that the particles do not adhere to the walls of the tube where they strike upon them, and the electrodes of tubes prepared for the observation of cathode radiation generally have their discharging surfaces made of aluminum.

There is no observable reflection of cathode rays from the walls of the tube, or from any surface upon which they may be made to impinge. A metal plate is heated by them. The glass walls of the tube are generally made to glow with a fluorescent light when the cathode rays beat upon them. In the German glass of which such vacuum tubes are generally made, this fluorescence is of a bright green color. It is especially marked in uranium glass, in which the color is of a darker green than in German glass. If brought to a focus upon the glass walls of the tube, they may heat the glass sufficiently to cause a puncture of the tube. If they are made to strike against the mica vanes of

FIGURE 5—Highly exhausted tube containing a fluorescent screen along which the cathode radiation is bent from "e" to "g" by the magnet beneath the tube.

a small paddle wheel, they set the wheel in rapid rotation. They are deflected from their straight paths when brought into a strong magnetic field, and are bent toward a direction at right angles to the magnetic lines of force. If they be regarded as made up of moving particles going out from the cathode, these particles are made to revolve about the magnetic lines of force in a direction opposite to the Amperian currents. Two parallel beams of cathode rays repel each other, like chains of similarly electrified particles, instead of attracting each other like parallel currents flowing in the same direction.

The above mentioned phenomena of cathode radiation are practically all discussed in the papers written by Hittorf in 1869, and by Crookes in 1879. In 1891, Hertz observed that the cathode rays could apparently be passed through thin metal foil and other opaque substances and still have sufficient energy to produce fluorscent effects. He observed also that if the rays are parallel before falling upon the metal foil, they are dispersed and rendered divergent by their passage through it.

In 1893, Philip Lenard prepared a vacuum tube with

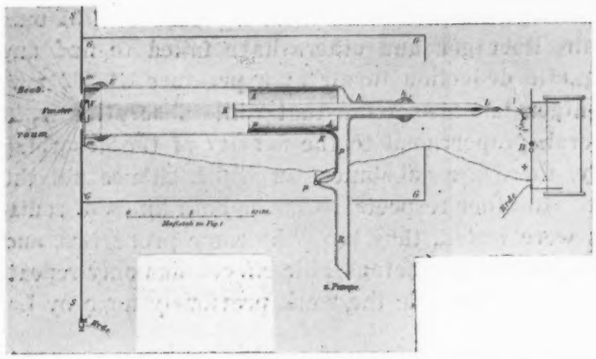


FIGURE 6--Cut of the lamp used by Lenard, showing an aluminum window at "V," which is connected with the earth and to the positive electrode.—Wiedemann's Annalen, Jan. 15, 1894.

a window 1.7 mm. in diameter at one end, over which he cemented a piece of aluminum foil about .003 mm. thick. When the cathode rays were directed against this window, they seemed to pass through it and to be dispersed in the outer air. Lenard was able to recognize their fluorescent effects upon various substances at a distance from 6 to 8 cm. from the window when using the discharge from an induction coil capable of giving a spark 15 cm. long in air. He found that the effect was equally strong in all directions from the aluminum window, showing that the radiation spread out in all directions after passing through the window into the outer air. He discovered also the photographic effect of these rays. He observed that ordinary photographic printing paper when placed near the window was blackened by these rays as rapidly as by the sunlight on a cloudy day. A sensitized plate when exposed to the rays (which gave no luminous effect in the air) at a much greater distance from the window for a few seconds and afterward developed was found to be blackened as if it had been exposed to sunlight. Lenard made photographs with these rays through opaque card board and through thin metal foil with an exposure of only two minutes, and observed the shadow images left upon the plate when thicker pieces of metal were laid upon it

He repeated these experiments with the rays which had apparently passed through the glass walls of his tube, but found their intensity to be less than when they had apparently passed through the aluminum window.

Lenard also passed the cathode rays, as he supposed, through the aluminum window into a vacuum tube exhausted to such a degree that no discharge could be passed between electrodes sealed into the tubes, and found them capable of producing in this tube all the effects produced by them in the tube in which they were originally generated, and in the outer air. He found that a large part of the dispersion formerly observed in the atmosphere was due to the presence of the air, so that a beam of parallel rays passed through the window into the vacuum became a moderately diverging pencil. He found them still capable of deviation by a magnet, and observed that the magnitude of this deviation remained unaltered when air was admitted to the tube, until the absorptive effect of the air made further observation impossible. He measured the magnetic deviation at air pressures varying from 31 mm. to .02 mm., and in hydrogen from 3.32 mm. to .02 mm., and found it to be the same in all cases, regardless of pressure. He observed that neither in a vacuum nor in the air were the rays capable of reflection from any kind of a surface.

Later, in 1895, Lenard tested the absorptive power of many substances, solids, liquids and gases, for the cathode rays, and found the absorptive power of different substances to be proportional to their density, irrespective of their chemical nature.

In 1894, J. J. Thompson observed the phosphorescent effect of the cathode rays upon a piece of ordinary German glass at a distance of several feet from the vacuum tube, even when the rays had to pass through the glass walls of the tube. He measured the velocity of cathode radiation in the tube by observing by means

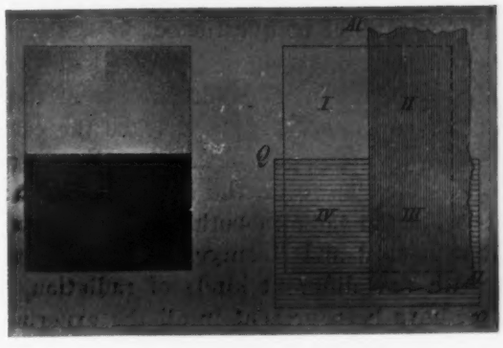


FIGURE 7--"A" represents a photograph taken by means of the apparatus in Figure 6, the radiation passing through the crossed sheets of aluminum and quartz, arranged as shown in "B."

of a rapidly rotating mirror the difference in time of the beginning of the phosphorescent effect upon two spots ten centimetres apart upon the glass wall of the tube when a discharge was passed between the electrodes. He found the velocity in a tube of rarified hydrogen to be $1.9 \times 10^{\frac{7}{8}}$ cm. sec., or about 100 times the mean velocity of the hydrogen atom at O. C.

In December, 1895, Roentgen announced that he had

observed the fluorescence of a paper screen prepared with a solution of the double cyanide of barium and platinum when it was placed at a distance as great as two meters from a tube in which the cathode discharge was taking place, even when the tube was covered with a screen of opaque paper. By placing dense bodies between the screen and the tube their shadows were plainly visible upon the screen. When the hand was held between the screen and tube, the denser bones were plainly outlined in shadow through the more transparent flesh. Upon exposing a covered photographic plate to the action of the rays which produced the fluorescence, as Lenard had previously done, he was able to develop photographs in which the bones of the hand and other dense bodies were plainly outlined in shadow.

Roentgen passed these rays through prisms of various liquids, of hard rubber and of aluminum, without producing any noticeable refraction. He was unable to reflect them from any surface, and he found that different metals in a finely divided form were as transparent as the same metal in a solid form, showing that there could be but little reflection at each metallic surface. He was unable to produce any magnetic deflection of the rays, or to polarize them. He also found that while their absorption increased with the density of the absorbing body it was not independent of the chemical nature of the body. He found on comparing the transparency of equally thick plates of glass, aluminum, quartz and calcite, all of which are nearly of the same density, that while the first three were nearly alike in their transparancy, the calcite was much more opaque.

These observations have all been repeated by many other physicists under widely varying conditions, and their accuracy can not be questioned.

Roentgen accordingly believes that he has been experimenting with a radiation different from the one which Hertz and Lenard supposed to be the cathode rays after they had been passed through glass or other substances. Since, however, the conditions of the experiments were the same in both cases, it seems certain that if Lenard and Roentgen have been experimenting with two different kinds of radiation, both kinds must have been present in all the experiments performed by either. The probability that different kinds of cathode radiation may exist at the same time in the tube has been previously mentioned. Goldstein, more than ten years ago, mentions the fact that while part of the cathode rays are deflected by the magnet, they exist with these others which are not capable of magnetic deflection. Lenard also calls attention to the fact that the degree of magnetic deflection of which the cathode rays are capable depends upon the degree of exhaustion of the tube in which they are produced. Roentgen has also called attention to the observation that the "X rays" seem to come from the part of the tube directly facing the discharging surface of the cathode, even if the visible cathode rays are deflected by a magnet to another part of the tube.

The differences in the experimental results of Lenard and Roentgen are not, however, sufficiently great to make it certain that they have been working with different kinds of radiation. These differences are, principally, that while Lenard found the atmosphere to act as a turbid medium for the transmission of his rays, Roentgen has found it to be apparently very transparent to the passage of the X ray, and while Lenard was able to show that the magnetic deflection of his rays was constant up to a pressure of 31 mm. in air, Roentgen and others have failed to find any magnetic deflection in air at a pressure of 760 mm. Roentgen has also found that while absorption is, in general, proportional to the density of the absorbing body, there are substances in which this is not the case. In other respects, so far as both kinds of radiation were tested, they have the same properties, and Roentgen, in his photographic effects, has only repeated on a larger scale the work previously done by Lenard.

The differences between these rays and other known forms of radiation are, however, more marked. These differences, as stated by Roentgen, are as follows:

(a) All other known forms of radiation are refracted when passing obliquely from one medium into another of different density.

(b) All other known forms of radiation can be regularly reflected from polished surfaces.

(c) All other known forms of radiation can be polarized.

(d) The absorption of all other kinds of rays depends more upon other properties of the absorbing medium than upon its density.

Since these differences are so marked, Roentgen asks if these rays may not be due to longitudinal vibrations in the ether.

The fact that they differ so greatly in some of their properties from the cathode rays within the tube has led Roentgen to the belief that they are set up in the walls of the tube by the impact of the cathode rays. This assumption gains in probability from the report that J. J. Thomson has tried to produce the same photographic effect by means of the cathode rays while in the tube and has failed. The reported results of different observers who have tried to determine the source of the rays are very conflicting, and it is probably not too much to say that their origin is still unknown. The probability of their being waves of longitudinal vibrations is somewhat strengthened by the fact that the present writer, in 1892-3, produced similar photographic effects in an oscillating condenser field where the vibrations were certainly of a longitudinal character.

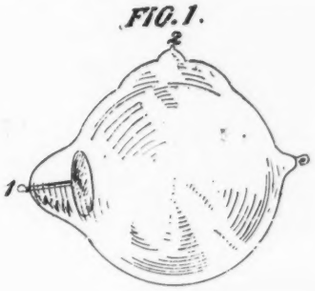
Part ii

ANODE RADIATIONS.

BY PHILIP MILLS JONES, M. D.

I commenced some investigations on the rays of Roentgen about the middle of February, and as the results obtained have been satisfactory, and in some lines, so far as I know, original, it has seemed to me advisable to place on record my data and the conclusions which I have deduced therefrom.

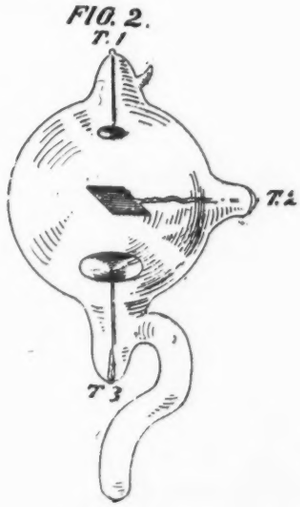
FIG. 1.



My electrical apparatus consists of an induction coil which, with seven volts in the primary, will give a four-inch spark in air. The interrupter is of the magnetic type, and gives about forty to sixty interruptions per second. The coil is energized by three storage batteries.

No standard Crooke's tube was obtainable when the work was commenced so I had recourse to Mr. L. G.

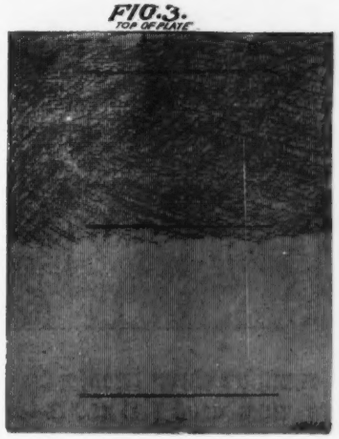
FIG. 2.



Lamont, a skillful glassblower and manufacturer of small lamps. Mr. Lamont had made no Crookes tubes, but between my suggestions and his skill we managed to produce a vacuum tube that gave results. The tube was generally spherical, with the terminals in the form of platinum disks one half inch in diameter, set at right angles (Figure 1), and which I shall, for reference, refer to as T_1 and T_2. The tube was of sufficiently high vacuum to give a brilliant green fluorescnce opposite the cathode.

This tube was suspended over a plate-holder containing the plate, on the slide of which were several metallic objects. The terminal T_2 was over the center of the plate and parallel to it, while terminal T_1 was in a plane verticle to the sensative plate and at right angles to T_2. Terminal T_2 was connected to the cathode

FIG. 3.

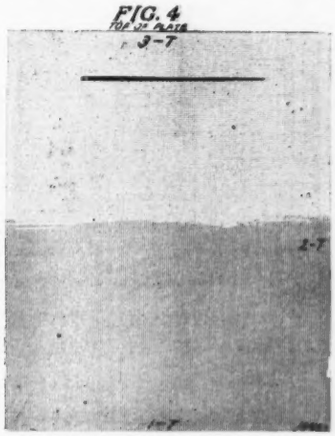


of the coil and a brilliant patch of fluorescence appeared opposite and on the glass directly over the plate. No result was obtained in any one of a dozen or more exposures of from an hour to two and one-half hours.

Then the poles were changed, terminal 1 was made cathode, the green patch appearing opposite it, and the plate exposed for one and one-half hours opposite T_2 (the anode), gave a fairly good negative of the objects on the plate-holder.

That was on February 18th, and at once I concluded

FIG. 4



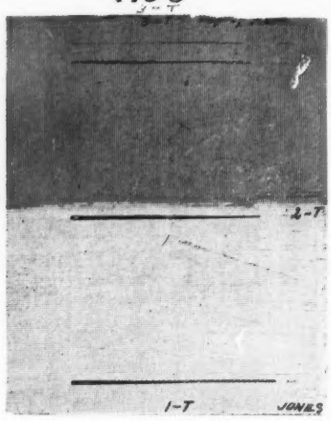
that the X rays were anode rays, or that the phenomena of vacuum tube polarity had been erroneously named. Further investigation has shown that the former was the correct conclusion, and that the X rays of Roentgen are of anode emanation.

After a few days a genuine Crookes tube of fairly high vacuum came into my possession, through the courtesy of the Santa Clara College. Drawing sug-

gestions from this tube Mr. Lamont has succeeded in perfecting vacuum tubes for producing the X-ray effects.

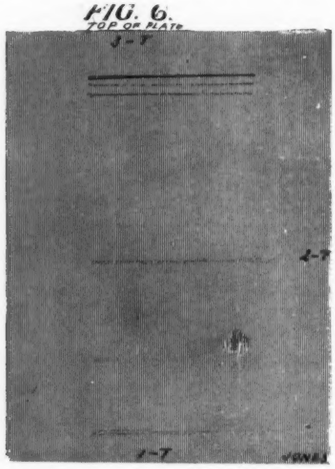
This tube (Figure 2) is of the same pattern as those used by Elihu Thomson and several other experi-

FIG 5



menters. It contains three terminals, which, for convenience, are numbered 1, 2 and 3—as in the cut (Figure 2). Terminal 1 (T_1) is an aluminum disk one-half inch in diameter; T_2 is a platinum plate one-half inch wide and five-eighths inches long; T_3 is a cup-shaped aluminum disk, with its focus at T_2. With this tube I noticed at once that the best results were obtained when the tube was so placed and connected that emanations from the anode were directed against the plate. But press of work prevented my going into the question for some little time. The work first taken up was largely investigating the extent to which the X rays would be useful in surgery and in testing plates

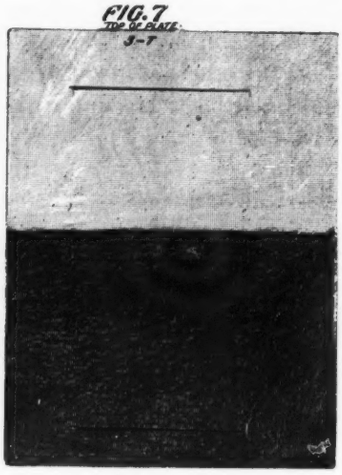
FIG. 6.
TOP OF PLATE
3-T



and developers, and in obtaining standards for comparison.

From time to time, as opportunity offered, I made rough tests to determine the point of origin of the rays by calculating the angles of distortion, and in every case the anode was the terminal which seemed to be responsible. With the tube verticle, T_1 down and connected so that T_1 was cathode and T_2 and T_3 anodes, the best results were obtained and the distortion was least. If, however, the polarity was reversed and T_1 made anode, with T_2 and T_3 cathode, the results were not good—longer exposures were required and great distortion resulted. With the tube in the position and

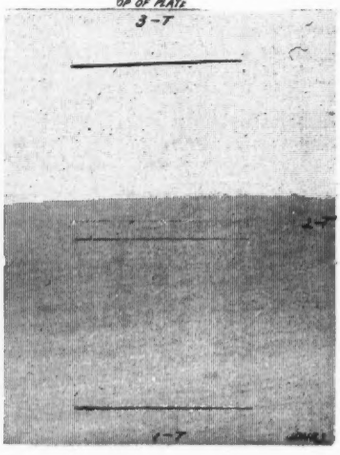
FIG. 7
TOP OF PLATE
3-T



with the connections first noted fair negatives have been obtained in thirty seconds, and good ones in one or two minutes. But I found my experience to be the same as that of Nikola Tesla, recently published, that while it is quite possible to get negatives in a few seconds or minutes, to obtain a good negative requires from fifteen minutes to one and one-half hours.

As soon as possible I commenced regular work on the investigation for the actual source of the X rays. It was evident that first I must know what effect would be produced by differences in the connections and direction of current; as will be seen, the three

FIG. 8
OP OF PLATE
3-T

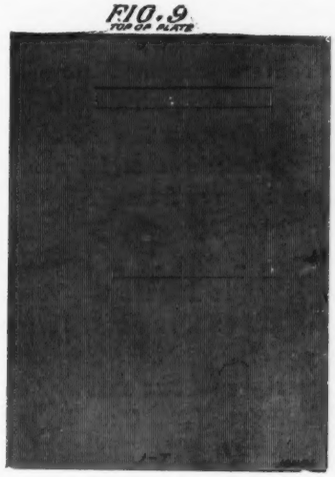


terminals admit of twelve possible combinations, and the effect of each one must be known. The experiments were made as accurately as possible; all conditions were as nearly the same as could be obtained. The plates were all of the same kind and the same emulsion; the relations between plate and tube were measured and adjusted several times, with rule and plumb line; the developer used was the same; the time

of development varied only one and one-half minutes, and was in most cases the same—three minutes.

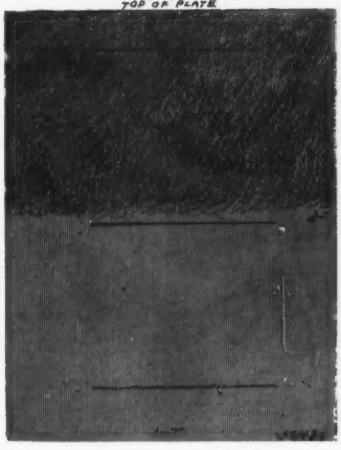
The tube was placed horizontally, with its line of center four and five-eighths inches from the film of the sensative plate; it was rigidly clamped in this position. The plate (4x5) was placed so that T_2 came over the center of the plate and the axis of the tube was parallel to the long edges of the plate. T_3 was over that end of the plate which will be throughout referred to as the "top of the plate." The plate-holder was fitted into thin strips of wood nailed to the table, so that it would in all cases have the same position with relation to the tube. The distances of the terminals apart is one and one-half inches; i. e. T_1 to T_2—one and one-half inches; T_2 to T_3—one and one-half inches; T_1 extends one-quarter inch, T_2, one-half inch, and T_3 three-quarter inches from the axis of their centers.

FIG. 9.
TOP OF PLATE



The objects used were needles, three in number, each thrust through a cork in such a manner that they would be parallel to the plate surface and five-eighths of an inch therefrom. They were, for accuracy, pasted to a sheet of stiff paper which exactly fitted the plate-holder slide. The needles will be referred to as N_1, N_2 and N_3; N_3 being at the top of the plate, or under T_3. T_2 was centered exactly over N_2. The needles were parallel to each other and one and five-eighths inches distant one from the next adjoining.

FIG. 10.
TOP OF PLATE

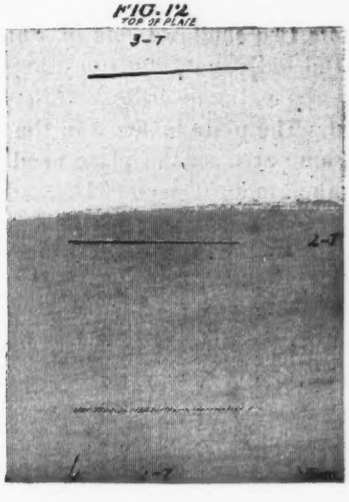


The exposure was in every case (except in subsequent work when some of the first twelve experiments were repeated) fifteen minutes. A slight variation in the intensity of the X ray effects was unavoidable, owing to a warming of the coil and a decrease of voltage of the batteries after several hours more or less continuous use. This variation, however, is not of particular import, for subsequent repetitions of the first twelve experiments do not show anything more than a slight increase in the density of the film; the positions or absence of shadows is the same.

FIG. 11.
TOP OF PLATE

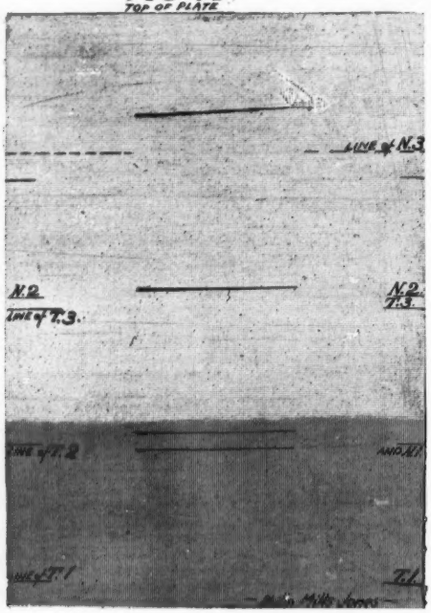
Experiment 1, with T_1 cathode and T_3 anode, gave the plate shown in Figure 3. Shadows appear at N_1, one-quarter inch below the proper place; N_2 centers, N centers, while N_1 and N_3 are not sharp, especially N_3. The lower half of the plate is more dense than the upper; the line of demarcation is quite sharp and is along the line of the center of the plate. Shadows of N_1 and N_2, if the angles are projected back, are found to be produced by rays from T_2. The shadow of N_3 is made by rays from T .

FIG. 12.
TOP OF PLATE



Experiment No. 2, with T_1 anode, T_3 cathode, gives plate as show in Figure 4. There are no shadows of N_1 or N_2. N_3 is sharp and one-quarter inch above (toward T_3 the location of N_3 The top half of the plate, from a point three-eighths of an inch above the

FIG. 14



line of center, is denser than the lower half and is also denser than the lower half of the plate in experiment No. 1. Shadow of N_3 was found to be produced by rays from T_2.

In experiment No. 3 with T_1 cathode, T_2 and T_3 anodes (this is the method of connection I have used for all my general X-ray work, as being most satisfactory), plate 1 (Figure 5) shows the shadow of N_1 to be one-quarter of an inch below position N_4. N_2 centers, N_3 casts two shadows, one of which centers but is blurred and indistinct, and the other is one-quarter of an inch above the position of N_3, and is sharp, though faint. The plate is dense in the lower half (being of the same area as the plate used in experiment No. 1, but much more dense). The shadows of N_1 and N_2 and one shadow of N_3, are cast by rays from T_2; one shadow of N_3 is cast by rays from T_3.

Experiment No. 4, with T_1 as anode, T_2 and T_3 as cathodes, gave a blank plate (N. B.—The tube was not so active in this experiment as in the others. A repetition with the tube active, however, gave only a faint shadow of N_1, which was in its proper place).

Experiment No. 5, with T_1 and T_2, as cathode, and T_3 as anode, gave the plate shown in Figure 6. Negative is of even density, with shadows as follows: N_1 is one-half inch below the location of N_1, N_2 is one-quarter inch below location of N_2. N_3 gave three shadows, (1) centers, (2) one-eighth inch above the proper place, and (3) one-quarter inch above the proper place. The shadows of N_1 is thrown from T_3, of N_2, from T_3 of N_3 there are two shadows (1) that centers, and one one-eighth inch up from T_3, while the third shadows of N_3 evidently comes from T_2.

Experiment No. 6, with T_1 and T_2 as anodes and T_3 as cathode, gave the plate shown in Figure 7. This plate, from three-eighths inch above the line of center to the top is very dense; the shadow of N_1 is one-quarter inch below N_1, but sharp. N_2 gives two shadows, one of which centers and one is three-sixteenths of an inch above N_2. The N_3 shadow is one-fourth of an inch above N_3. The shadow of N_1 is cast by rays from T_2. If the shadows of N_2 are cast by rays from T_1 and one by rays from T_2, the shadow of N3 is cast by rays from T_2.

Experiment No. 7, with T_2 as anode and T_3 as cathode, gave the plate in Figure 8. This plate is dense from about one-half an inch above the line of center to the top of the plate. Shadow N_1, one-fourth of an inch blow N_1. N_2 cast two shadows, one centers and one one-fourth above N_2. The N_3 shadow is one-fourth of an inch above N_3. The shadow of N_1 is cast by rays from T_2; in that of N_2 one shadow is made by rays from T_1 and one by rays from T_2; of N_3 by rays from T_2.

Experiment No. 8, with T_3 as anode and T_2 as cathode, gave the plate on Figure 9. The plate for the same distance from center to top is slightly denser than in the lower part. There is no shadow of N_1; a very faint shadow of N_2, one-fourth of an inch below N_2; two shadows of N_3, the faint one centers and the other is clearer, one-fourth of an inch above N_3. The shadow of N_2 is thrown by rays from T_3 one shadow, N_3, is by rays from T_3 and one by rays from T_2.

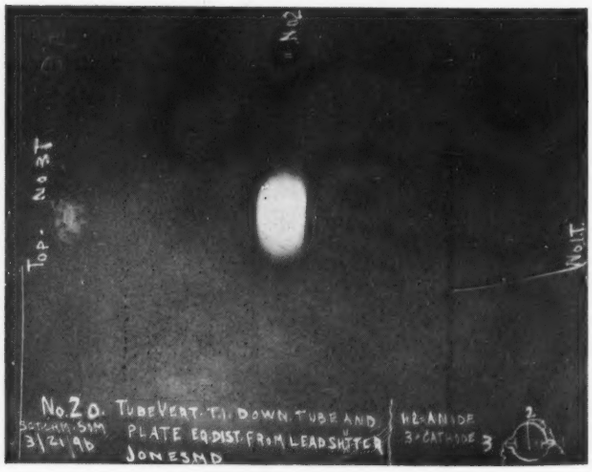


FIGURE 15—A Pin Hole Negative.

Experiment No. 9, with T_1 as cathode and T_2 as anode, gave the plate in Figure 10, which, from a little above the line of center to the bottom, is slightly denser. The shadow of N_1 is blurred, though plain, and one-fourth of an inch below N_1; the shadow of N_2 centers, and that of N_3 is one-fourth above. All three shadows are thrown by rays from T_2.

Experiment No. 10, with T_1 as anode and T_2 as cath-

ode, gave a blank plate. (Note. The tube was again not fully excited; a repetition of this experiment at a subsequent date give a faint shadow of N1 in the proper place.)

Experiment No. 11, with T_1 and T_3 as anodes and T_2

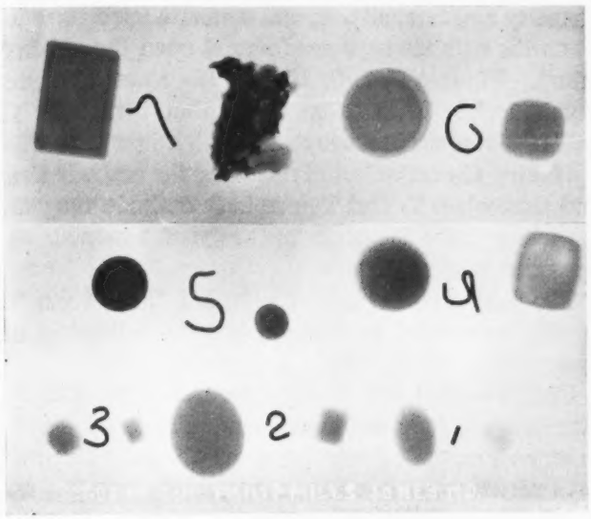


FIGURE 16--Illustrating the relative sensity of precious stones.

as cathode, gave the plate in Figure 11, which is of even density, and showing the shadow of only one needle; N_3, which is one-fourth of an inch above the location of N_3. The shadow in this case must have been thrown by rays from T_2.

Experiment No. 12, with T_1 and T_3 as cathodes and T_2 as anode, gave the plate Figure 12, which is very dense from the same line to the top. The shadow of N_1 is blurred, though very plain, one-fourth of an inch below N_1; of N_2 the shadow is sharp and centers; of N_3 it is sharp and one-fourth of an inch above the position of N_3. All three shadows must have been thrown by T_2, as can be seen by projecting out the angles of distortion.

Many, in fact most, of these experiments have been repeated several times—some of them as many as ten or twelve times. To see whether the obvious conclusions to be drawn from them were substantiated by other tests, another series of experiments was made, the second form of experiments being, if anything, more striking in their results.

The tube was arranged vertically, with T_1 down. A plate in a plate holder was placed perpendicularly, parallel to the long axis of the tube, and with its central point in the plane of T_2. Both tube and plate were equidistant from a sheet of lead in which was a hole three-sixteenths of an inch in diameter, and on the plane of T_2 the center of the plate. As lead cuts off almost all the X rays, it will be obvious that the resultant negative would be a "pin-hole" picture, giving the source of emancipation of the X rays.

This experiment was made ten times, with several different arrangements of anode and cathode, and the results were strikingly similar. In every case T_2 threw a heavy shadow, whether it was connected to the anode or not; in no case did any terminal which was connected with the cathode throw the faintest shadow; the anode terminal always threw a shadow, but if it were T_1 or T_3 it was not so dense as that from T_2.

Figure 15 is one of these "pin-hole" pictures, with the tube connected so that T_1 and T_2 are anodes and T_3 is the cathode. No X rays came from T_3 and but few from T_1, while the very heavy shadow of T_2 shows that the maximum number of X rays emanated from that point.

Figure 14 shows the distortion much more clearly, and was made on a 5x7 plate with the object of getting more angles for projection. The tube was connected with T_1 and T_2 as the anode and T_2 as the cathode, and T_3 as the cathode and was arranged as in experiments 1 to 12, except that N_2 was exactly centered under T_2. The distances were afterward carefully measured and the positions of the terminals and needles marked on the plate. N_1 threw two shadows, one from T_1 three-sixteenths above N_1, and one from T_2, exactly centering in its proposed plane. The shadows of N_2 and N_3 were both thrown by rays from T_2, as can be readily seen by projecting the angles of distortion.

These experiments with their many repetitions and slight changes seemed to furnish a mass of very confused and contradictory testimony. From this confusion, however, I have evolved some order, and have de-

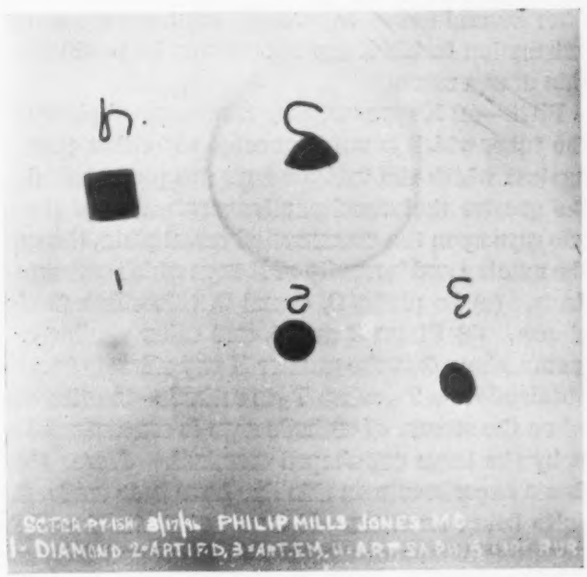


FIGURE 17--Illustrating different opacity of genuine and artificial gems.

duced several general principles, the truth or falsity of which will undoubtedly be more manifest within a short time.

First.—That the X rays do not emanate from the glass, as advanced by Roentgen. This has been shown also, by J. J. Thomson, Lodge, Professor Rowland, and

others. If the X rays did emanate from the glass at any point, that fact would be made known by the pin-hole experiment; also the distortion would always be considerable, unless the tube were placed at some distance (several feet) from the plate.

Second.—The X rays do not emanate from the cathode terminals, as Figures 6-9-11 would at first glance seem to indicate. This point will be dealt with later. Professor Rowland, Elihu Thomson, J. J. Thomson and others have in various ways demonstrated the absence of X ray effects from the cathode. All my experiments (with the exceptions above noted) and all "pin-hole" experiments, substantiate this contention. No X rays emanate from the cathode, per se.

Third.—A certain number of X rays emanate from the anode, irrespective of position of the cathode. In every combination of the connections in the tube Figure 2, some X ray effects are produced by the anode. In tubes made with the terminals at right angles and so constructed that few if any cathode rays can strike upon the anode, as the tube in figure 1, X rays are found to emanate from the anode.

Fourth.—The number and intensity of the X rays emanating from the anode, per se, seem to increase directly with the vacuum and the current tension. With a tube similar to Figure 1, but a low vacuum—just high enough exhaustion to produce cathode rays—feeble X ray effects are obtainable with the anode terminal directly above and parallel to the plate. With the anode perpendicular to, and the cathode stream directed upon the plate, no X ray effects have been produced even after several hours' exposure. With vacuua of higher exhaustion feeble X ray effects may be produced with this arangement.

Fifth—(a) X rays emanate from a metal plate within the tube, which is not connected to either pole, but against which the cathode rays are projected; (b) and the greater the intensity and concentration of the cathode rays upon the unconnected metal plate, the greater the number and intensity of X rays which emanate here from. (a) In plates 3, 4 and 8, this effect is clearly shown. (b) Plates 3 and 4, and other similar experiments, show that the greater X ray effect is invariably obtained from T_2, when T_3 is cathode—in other words, when the stream of cathode rays is concentrated upon it by the large cup-shaped terminal. More than a dozen experiments on this line have been made, the results being constant. It does not make the slightest apparent difference whether T_2 is grounded by means of straight wire or through a large coil where the self-inductive effect would be considerable. This fact has not heretofore been noted.

Sixth.—An unconnected metal plate within the tube may project X rays where it is not connected to either terminal, and when a metal plate intervenes, cutting off the cathode rays. This is shown in plate 8, excepting No. 7, where the second shadow of N_2 is thrown three-sixteenths of an inch up, showing that the source of rays making the shadow was T_1. Yet T_1 was not connected, and T_2 cut off all apparent cathode rays from striking upon T_1. It would, however, be possible for T_1 to become charged by the stream from T_2.

Seventh.—X rays are produced in their maximum quantity and intensity at, and emanate from the anode, when the cathode rays are focused upon the anode terminal. Figures 5, 7, 8, 10 and 12 show this pretty conclusively. It is to be noted that invariably that half of the plate is more dense which is on the side of T_2, facing the cathode and receiving the cathode stream and that when T_1 and T_3 are both cathode the side of T_2, which faces T_3, projects the greater number of, or the more intense, X rays.

The foregoing seven deductions, I think I am thoroughly warranted in making, but the following, however, admits of dispute:

Eighth.—That the X rays, focused upon a cathode terminal, are reflected therefrom. Figures 6, 9 and 11, in experiments 5, 8 and 11 show shadows thrown by rays which must have been projected from T_2, while T_2 was connected to the cathode.

On March 16th and again on March 28th, I had the pleasure of going over my work with Professor Sanford, who is of the opinion that the deductions drawn from the results, as set forth, are justified, with the possible exception of the eighth, which needs more confirmation. On March 18th I informed Professor Cory of the University of California of the nature of my investigations and conclusions. He has subsequently made several experiments along the same line, with results that substantiate my own.

It seems clear, then, that we have: (a) some X rays emanating from the anode uninfluenced by the cathode; (b) more from an unconnected plate of metal, in the tube, which is situated in the path of both anode and cathode raye, and (c) the maximum intensity when the cathode rays expend their energy upon the anode, and preferably are focused upon the anode. These facts would seem to indicate that the X ray has its origin at a metal within the vacuum which is in a state of oscillatory electrification, with the positive in preponderance and are longitudinal ether waves.

The theory advanced by Thomson, Lodge, Hicks, and others, that the X rays emanate from the first solid upon which the cathode rays impinge, it seems to me clearly disproved by the experiment of J. J. Thomson. He enclosed a wrapped sensatized plate within the vacuum so arranged that the cathode rays impinged upon it. The plate was unaffected.

The plate in Figure 16 shows the relative density of several precious and semi-precious stones. They are, in the order named, as follows: Diamond, 1. opal, emerald, 2 jade, ruby, 3 sapphire, sard, 4 amythist, pearl, 5 enamel, bloodstone, 6 white onyx, quartz, 7 sardonyx.

Figure 17 shows the difference in opacity to the X

rays, of a genuine diamond and several artificial stones and illustrates one use to which the X rays may be put. The genuine and artificial diamonds were almost exactly the same size and were exactly the same weight.

Part iii

DEDUCTIONS FROM DR. JONES' EXPERIMENTS.

BY FERNANDO SANFORD,
Professor of Physics, Leland Stanford Junior University.

I have watched with much interest the results of the very intelligent and accurate work of Dr. Philip Mills Jones on the determination of the source of the Roentgen rays. Some of Dr. Jones' experiments were performed in my presence, and I have had the pleasure of examining all his negatives in the presence of the apparatus by which they were made. The great care taken in all the details of the experiments renders the work of special value in helping to settle the puzzling question of the source of the photographic and fluorescent effects to which Roentgen has called the attention of the world. Dr. Jones' first experiment with the lead plate camera was performed in my presence and at my request, and the result seemed to point conclusively to the anode as the source of the Roentgen rays. His later experiments, together with his former experience in making photographs by means of a tube in which the electrodes were inserted at right angles to each other, all seem to show that few, if any, of these rays originate at the cathode, or in the glass upon which the cathode rays impinge. They may originate at the anode, whether the cathode rays do or do not impinge upon it, and they may originate upon it, and they may originate upon an insulated or uninsulated metal plate placed in the pathway of both the cathode and anode discharge. In this event they are much stronger from the side of the plate turned toward the cathode. The most favorable condition for their production seems to be when the plate from which they proceed is made the anode and the cathode rays are focused upon it by means of a concave cathode.

Under all the circumstances of their production, as shown in Dr. Jones' experiments, they have their origin upon a conductor which is being alternately, positivly and negatively electrified. There can be no question as to the oscillatory character of its discharge in the vacuum tube, and of the consequent alternating electrical condition of the anode when the cathode is discharging directly upon it. The same thing would be true, to a less extent, of the metal plate in the pathway of the two discharges. The condition of the anode would, accordingly, be similar to that of one of the plates of a condenser placed in contact with the terminals of an induction coil while a spark is passing between these terminals.

That a plate so connected is capable of producing photographic effects similar to those produced by the anode in the vacuum tube was shown by me in 1893. Since the publication of Roentgen's paper I have produced similar effects through a block of paraffine two centimeters thick placed between the plates of a condenser attached to the terminals of an induction coil while the coil was giving a spark two to three centimeters long in air. A key imbedded in the paraffine block gave a shadow exactly corresponding to the Roentgen shadows, but when placed very close to the plate, being separated only by a thin sheet of mica, gave a negative photograph of itself upon the plate, even when separated from the condenser plate by the block of paraffine above mentioned. In this condition it seems to correspond to the plate between the anode and cathode in the vacuum tube, but its effect in sending off waves was apparently very weak as compared with the condenser plate.

I have also made shadows of a thin sheet of mica laid on the photographic plate under the paraffine block, showing that mica is more opaque than paraffine to the passage of the vibration between the condenser plates.

Since these conditions correspond so closely with the condition of the conductor which sends off the Roentgen rays. I cannot but think that both kinds of waves are essentially of the same character, in which event the Roentgen rays are similar to the longitudinal vibrations in an oscillating condenser field.

Physics

THE DETERMINATION OF A LIGHT UNIT.

BY D. W. MURPHY.

Within the past few years the determination of a light unit which should be suitable as a standard with which other light sources could be compared, has received no little attention in the scientific world. We are accustomed to define the amount of light given off by a source as being equal to that of some number of standard candles, by a standard candle meaning one that consumes a unit mass of wax, paraffine or other combustible substance in a unit of time. The amount of light from such a standard is necessarily a variable quantity, as it depends upon the purity of the substance consumed, and, as is the case with all flames, upon the meteorological conditions of the atmosphere. The former source of error can be reduced to a minimum by using a more defined substance; and corrections based upon experimetal data can be made for atmospherical changes, reducing the results to standard conditions. The final test, however, for such a unit as a standard, is whether in the hands of different observers concordant results can be attained. This has not been attained by any form of candle yet used. Meas-

urements upon a paraffine candle in use for many years and adopted as a standard in Germany show that these variations were not less than 10 per cent.

The principal requirements of a light unit that will be serviceable as a standard are, first, that it shall be constant, and second, that it be simple enough in construction that it may be readily reproduced. The first requirement is one of a purely scientific nature, and may aid in the solution of the problem from a practical standpoint just in proportion as the second requirement can be realized. Since no standard yet prepared has given constant results in the hands of different observers, various attempts have been made to find some more reliable source with which comparisons can Vernon Harcourt. These are both open flame lamps, be made. To this end various light units have been proposed; among the most prominent of these should be mentioned the Heffner lamp and the pentane lamp of the substance used in the first being amyl acetate and in the second pentane. M. Vioele has proposed as a

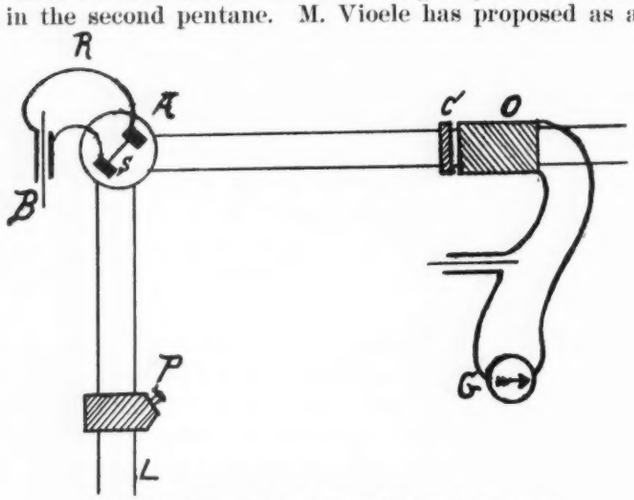


FIGURE 1—Scheme of the Lummer-Brodhum Photometer.

unit the light emitted from a square centimeter of platinum at its temperature of volitization. This, while it would seem to promise good results, has not met with success in the hands of other observers. Another standard proposed independently by Professor S. P. Thompson and Mr. James Swineburn was to use the light given off from one square millimeter of the crater of the positive carbon in the electric arc lamp. None of the standards, however, together with the many more that have been proposed, have fulfilled the conditions required of a practical light unit. At the International Electrical Congress held in Chicago in 1893 attempts were made to bring about the adoption of a unit. Of those considered by the committee the Heffner and pentane lamp were the most promising. Objections were made to the Heffner lamp that the flame was yellow in color, and to the pentane lamp that the commercial pentane is not sufficiently well defined. Finally the objection was made to all open flame lamps that they are too much affected by the temperature, pressure and moisture of the air.

The committee recommended that while its members realized the great progress made by the constructoion of these lamps, yet it was unable to recommend either as a light standard. It further invited all nations to make researches in common on practical, well defined standards, in the hopes of realizing an absolute unit. Since that time some further progress has been made and other forms of units have been proposed. The most of these, however, are mere proposals of what may be a constant source, but lacking careful experiments to recommend them to favor.

The following method of determining a light unit and the one which seems to promise best results so far attained has been used by Professor Lummer and Dr. Kurlbaum of the Physikalisebe Reichsaustalt. As a unit is used the light emitted from a square centimeter of platinum kept at a constant temperature. The platinum strip is heated by an electric current; the temperature is defined by the relation of the amounts of its radations under different conditions. The one is the total radiation of the heated platinum, the other consists of the rays which pass through a definite absorption medium. So long as the ratio of these two remain the same the temperature of the course is constant. The amounts of these radiations are measured by means of the balometer. The principles of this instrument, the use of which has been far reaching in physical investigations, were first worked out by Suanberg and later, but independent of him, by Langley.

The essential part of the instrument consists simply of a high resistance placed in an electric circuit; on this high resistance part of the circuit radiations are allowed to fall and the change in the resistance due to the temperature change measures the intensity of the radiations.

The apparatus used by Drs. Lummer and Kurlbaum consisted of a balometer, with galvanometer and other accessories for indicating changes in resistance, together with the light source, which consisted of a strip of platinum of approximately 25 millimeters wide, 60 milimeters long and 0.015 milimeters thick, so mounted that it formed part of an electric circuit. The platinum was heated to a high temperature by an electric current, whose strength could be regulated by a variable resistance. The light source was mounted on a form of optical bench, with two arms at right angles to each other. Upon the one arm the balometer was mounted, and upon the other a photometer. By rotating the light source, which was at the junction of the two arms, on a vertical axis comparisons could be made either on the balometer for the intensity of the radiations or on the photometer for the light intensity. The photometer used was of the Lummer-Brodhun type; the light with which the standard was compared was an incandescent lamp burning under a current of low intensity.

Previous results show that by burning a lamp in this manner its intensity could be kept constant for a very long period.

The general scheme of the apparatus is shown by Fig. 1. A is a circular plate of marble upon which the platinum strip, S, is mounted. A is so made that it turns about an axis passing through its center. The platinum, S, is connected with copper electrodes, which are connected with the battery, B. R is a variable resistance. In the one arm of the bench is the box, O, which contains the balometer,, which is connected on a battery circuit with the galvanometer, G. Between the light source and the balometer is placed the absorption cell, C. This cell is supported on a moveable screen so that it may be carried out of the path of the ray when it is desired to allow the entire radiation to

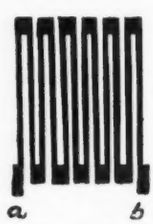


FIGURE 2

fall upon the balometer. On the other arm of the bench P and L represent respectively the photometer and the lamp against which the standard was compared.

The balometer was made in the following manner: A platinum plate is placed between two silver plates of some ten times its own thickness; the plates are then passed through rollers, the distance between which is constantly decreasing. As the silver plates become thin they are strengthened by being placed between copper plates and the rolling continued until the platinum is of the required thickness. In this manner a coherent piece of platinum as thin as 1-3,000 millimeters may be obtained. For practical working, however, a thickness of about three times this amount was more satisfactory. The thickness of those used in the experiment was 1-1,200 millimeters. When rolled to this thickness the silver adheres firmly to the platinum and serves as a vehicle for handling it in a manner that would be otherwise impossible. The silver sheet is then mounted on glass with Canada balsam and cut on the dividing engine in the form shown in Fig. 2. The twelve strips are each 1 millimeter wide, 1.25 millometers apart and 3.2 centimeters long. The plate often being cut in this form is mounted on a frame of slate, the extremities being soldered to copper electrodes.

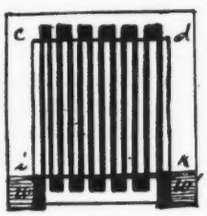


FIGURE 3

Fig. III shows the manner in which the mounting is done; c, d, k, i is the frame of slate, w and w' the copper electrodes to which the extremities of strips are soldered. After the mounting has been done the silver is removed by immersing in nitric acid.

The surface of the platinum is blackened in order that it may absorb all rays received upon it. The blackening was done by means of platin black, thrown down by electrolysis, in a weak solution of platin chloride.

The plate is removed from the glass by chloroform and fastened to the frame by means of resin dissolved in ether. To protect the extremities of the strips from the action of the acid they are covered with Japanese varnish and hyprochloric acid. Two balometers prepared as above described were placed one behind the other so that the strips of one covered the spaces of the other, thus forming a nearly continuous surface on which the radiations were received.

The two pairs of balometers were connected so that they formed the four arms of a Wheatstone bridge. The radiations fell upon the two opposite arms of the bridge.

The balometers mounted in the form for use are shown in Figure 4. The two pairs are mounted in the hard rubber standards, h and h'. The radiations fell upon them in h. The openings, S, allow air to circulate freely through the apparatus. The plate is of copper, blackened so that it will absorb all rays which fall upon it and serves as a screen to protect the balometers mounted in h'.

The absorption cell consisted of a ring of glass with sides formed of parallel quartz plates. The quartz plates were 1 millimeter thick and 2 centimeters distant from each other. The cell was filled with pure water.

The temperature of the glowing platinum was so regulated that the total radiation which fell upon the balometer was to that which passed through the absorption cell in the ratio of 10 to 1.

From a consideration of the curve of the intensity of radiations it is clear that this could be the case only when the temperature of the radiating source remained constant.

The amounts of the radiations were measured by the galvanometer deflections. Since it was impractical to work with deflections one of which was ten times as great as the other, the deflections were made equal. For this three different methods were used. The first was to shunt the galvanometer so that only 1-10 of the current passed through when the total radiations were received.

The second was by changing the resistances of the entire circuit so that their values were in the ratio of 10 to 1 for the total and partial radiations. This method was practical for relative feet, not for absolute measurements.

The third method consisted in changing the distances of the balometer from the radiating source so that the distance for the total radiations was to that of the partial radiation in the ration of the square root of 10 to 1.

At a fixed distance before the glowing platinum a diaphragm of exactly 1 square centimeter area was placed; the light which passed through this diaphragm was taken as the unit.

During the experiments the temperature of all parts of the apparatus, whose temperature change could affect the results, was kept constant by being enclosed in hollow-walled cases through which water was allowed to flow.

In order to reproduce this light unit it is necessary to measure accurately the size of the diaphragm and the thickness of the absorption cell, since these are the sources of error which most affect the results. Another but very small inaccuracy is introduced by a change in the thickness of the black on the balometer. It was found that a change of 50 per cent in the thickness of this black gave a change of 2 per cent in the light unit. This, however, is small when we consider that the process of blacking is based upon conditions

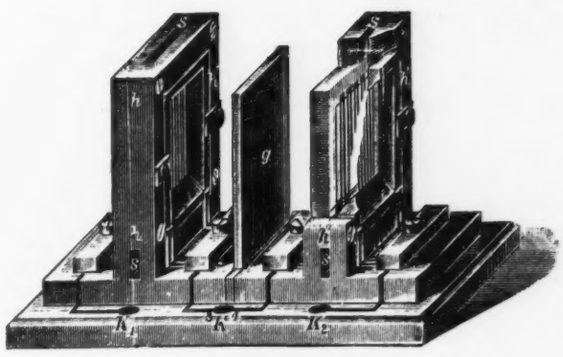


FIGURE 4--A two-pair set of Balometers.

quite readily reproduced, so that the errors in the thickness of the black may be made very small.

A series of observations made with different balometers prepared in the same way gave results, the greatest variations of which were 0.6 per cent.

The above method shows it to be possible to define a light unit in terms of absolute units. It is, however, only a definition and not an expression for the unit in absolute terms. As the term light involves not only the energy of the vibrating particle but the physiological effect upon the retina it is impossible to express a light unit in absolute terms in that manner that we are able to express a unit of work. It is therefore im-

possible to express it in terms of C. G. S. system or at present in any known system, as we know that for lights of different colors, the effect produced is not proportioal to the energy of the vibrations. The difficulty then lies in the comparison of different lights with a standard. It is well known that one of the greatest difficulties in photometric work is the comparison of lights of different colors. The composite thing known as light is, according to the generally accepted theory, made up of the action of a large number of different vibrations. Each vibration produces a different effect upon the eye and the relations of the intensities of the different vibrations determines the nature of the light source. This is shown in the different spectre produced by lights of different nature. We do not know the relative values of different colors in terms of the effect they produce upon the retina. We are then unable to compare the values of the two complex quantities without knowing the relative values of their component parts. In this sense we may say that a light unit is impossible, and so far actual experience has shown it to be true. Attempts have been made to solve the question by using different standards for different colored lights. This would in a way obviate the difficulty, but would give us no standard unit, but different units without a knowledge of their relative values.

Any complete method of comparing two light sources is one that will take account of all colors which are contained in the sources. This implies the valuation of the different colors in terms of their physiological effect in enabling us to see objects about us. A complete unit is one the component parts of which are known so that the above comparisons can be made. We must therefore conclude that in its broadest sense we are very far from a complete solution of the problem of an absolute light unit, and so far that it is not even shown that in its complete sense such a light unit is possible.

Passing Comment

AN EDITORIAL REVIEW OF CURRENT EVENTS AND PUBLICATIONS OF OUR CONTEMPORARIES.

THE DEFICIENCIES OF AMERICAN ARC LIGHTING SYSTEMS.

The system of arc lighting used at present in this country is so entirely an American development that we are inclined to neglect the progress which has been made in other countries, and to forget the fact that our methods suffer somewhat from a very early origin of the system, and its exceedingly slow and gradual development. Professor S. P. Thompson has pointed out on more than one occasion that arc lights are more easily run from machinery having a high coefficient of self-induction and has stated that this self-induction of the generating apparatus is more important in an arc lighting system than any possible increase in the efficiency could be and this statement embodies a theory that has been put in practice in all American arc lighting development without regard to the fact that the more recent arc lamps have been so greatly improved and the quality of the arc carbons so much advanced that the force of the argument is much weakened.

As Mr. Alex. Dow has indicated in his articles for December and January in "Electrical Engineering," arc lighting development has proceeded along the lines of larger generating units for the purpose of increasing the engine emciency without necessarily increasing the efficiency of the electrical generating apparatus. In the March number of this publication Mr. John Hesketh of Blackpool, England, has criticised the American practice from the point of view of an engineer familiar with methods almost unknown in this country, and he has made the very strong objection to our line of progress that the increase in size of steam generating units allowed by the use of 100 light and even 150 light arc machines does not always compensate for the disadvantages of excessive voltage and excessive length of circuits. Mr. Hesketh is an electrical engineer of a station using Ferranti rectifiers, delivering uni-directed constant current from the mains of a constant potential alternating system—a method which allows the employment of emcient generating apparatus, both steam and electrical, and permits the emcient connection of both arc and incandescent systems to the same set of the mains, while limiting the length and potentials of the arc circuits to that necessary for the connection of forty lamps in series.

The Ferranti rectifier, while perhaps not as efficient as the rotary transformer, at the same time is capable of delivering a constant current with a complete transmision efficiency better than can be obtained from the 100 light arc units, when we consider all the losses incident to the employment of small steam units, belt connections, inefficient electrical generating apparatus and lines of excessive length. From Mr. Hesketh's report we are inclined to believe that the Ferranti rectifier may be easily established in substations and the complexity of wire for a large district materially reduced and we are fain to believe that with an increasing appreciation of the losses incident to the installation of small transformers for incandescent lighting, more and more substations will be installed in the larger cities, and that where such substations are used the advantage of short arc lines supplied from current rectifiers will appeal to American engineers as furnishing a more satisfactory method of arc light installation than is to be found in the present tendency toward high potentials and long arc lighting circuits.

THE INFLUENCES OF ATTRACTIVENESS ON STATION ECONOMY.

It is gratifying to notice from an article by Mr. E. T. Adams in the "Engineering Magazine" for March that electrical engineers are beginning to realise the importance of carefully planned surroundings for their generating machinery. Most of the plants described by Mr. Adams have been carefully put up for advertising purpose, though enough instances are given of truly commercial plants carefully planned to indicate a tendency in this direction in central stations. More than ten years ago this subject was discussed before the cotton manufacturers' association of New England and it was at that time believed by them an expenditure amounting to as much as 1 per cent. of the capital stock of the company, was justified in the engine room of a great cotton mill, the principle being held that from the engine room an influence emanated which determined the character of the workmen throughout the plant and the care they were willing to give to the machinery under their charge. In any manufacturing company the employes of the engine room form a sort

of mechanical aristocracy whose methods and habits are copied throughout the entire plant. If the engine room is so fitted up and lighted so that it affords a pleasant living place for those employed there they will take an interest in the proper care of the machinery and personal neatness is fostered with the effect of materially reducing the repair bills not only at this one point but throughout the entire establishment.

As the engine room becomes more important this principle can be carried further and further. A far wider influence extends from the engine and dynamo room of an electric generating station than is possible from the engine room in any manufacturing concern, every workman about the entire plant is employed for some part of his time in the station itself; lamp trimmers are sometimes used in the station as lamp adjusters; linemen construct the station circuits, and so we might go through the whole force of employes and find that at some part of each man's time he is employed about the generating apparatus. If this generating apparatus is accurately installed, if all parts of the system are easily inspected by a superintendent or by visitors, if the tendency towards dinginess is removed from the entire plant, no man will be willing to have his own work pointed out as a disfigurement and the habits of careful and neat workmanship thus engendered will be reflected in his manner of performing his particular specific duties. At the same time good workmen are systematic opponents of ornateness or inappropriate decoration; carvings and scroll work about a switchboard form an unnecessary item of care in a plant, and while the designer should strive to make the plant as attractive as possible, no detail of accessibility should be in the least sacrificed. Concealed steam pipes and wires do not improve the appearance of an engine room or dynamo room, nor are breakable ornaments to be thought of in such a location, but only neatness and convenience are to be sought after. Colors should be chosen which will show at the same time when they are soiled and be capable of being kept clean with a reasonable amount of care. The artistic effect of fitness in such a place is the only artistic effect that is at all allowable, and when the plant is admirably installed for its purpose, it is at the same time admirably decorated.

TESTING ARC-LIGHTING CIRCUITS.

Mr. Alex Dow has been writing a series of papers upon arc lighting and arc-lighting circuits in "Electrical Engineering," which point to Mr. Dow as a practical engineer with a very clear perception of the practical needs of the business. In the January number the question is taken up not from the standpoint of the possible perfection of the line, but from the far more rational ground of the greatest possible economical efficiency of line. While the tests described do not attempt to apply theoretical principles they do give instructions for ascertaining whether any particular lighting line is in its best possible condition. The absolute insulation resistance tells very little, but the behavior of the insulation during the test may indicate to an experienced engineer the condition of the circuit.

No matter how good the insulation resistance of a submarine line may be it is defective if electrification proceeds irregularly. In the same way Mr. Dow points out that the absolute resistance of an overhead line does not indicate its character as well as its behavior during a storm. Should the insulation fall at first, then rise as the storm proceeds, and rise rapidly when the rain has stopped, the insulation of the line is good, for the rain, in wetting the insulators, has also washed them, but if the wet line falls in insulation and does not immediately rise again we are made aware of a fault which must be located and eliminated. This simple observation shows whether an overhead line is clear or defective and there seems at present to be no other manner of distinctly indicating this condition.

AN UNWARRANTED CONDEMNATION.

One can hardly agree with the universal condemnation of the business methods employed by electrical manufacturing and supply houses expressed in the article on the "Commercial Exploitation of Electricity" by B. E. Greene and published in the Feburary number of the "Engineering Magazine." Electricians can undoubtedly make allowances for Mr. Greene's own attitude of mind in such matters and can see in his article the effects of his long campaign against one particular manufacturing company, but the authority given to his opinons by publication in the "Engineering Magazine" renders them more worthy of attention than has been the case with the publications heretofore.

There appears to be no doubt but that the management of the great manufacturing companies sought for many years to make their money through stock operations rather than in the legitimate channels of manufacturing business, but when the author includes in the condemnation of such business methods the management of all electrical undertakings before the year 1886 he stands self-condemned as misrepresenting facts. Before the year 1885 the secretary of the Bridgeport Brass Company informed the writer that he held stock in almost every New England electric light company and that they were all showing small but constant earnings. Since that time many wildcat schemes have been begun and many failures made, but on the whole the electric light supply and the electric railroad businesses have been supported by sound earnings. The great array of incorporations shown by Mr. Greene for New York State between 1875 and 1895 prove nothing whatever, since in every line of business incorporations are excessive and to pick out the incorporated companies is at once to include all those branches of any business which are at all suspicious. Unreasonable business methods in electrical engineering have brought their own punishment in the past and are daily bringing yet more punishment just as is the case when the real estate values of any town have been boomed. But as costly experimentation has rapidly developed sound engineering in the same way costly financiering has developed a more perfect understanding of the value of electrical properties amongst monied men and has rendered the general tone of electrical business as sound as that of any other industry in the country.

NO USE FOR THE X-RAYS.

Said the maiden, archly smiling:
"Why all this cathodic fuss?
Men should know we've long seen through them,
But they'll never see through us."

— San Francisco Examiner.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of Electricity, Gas and Power.

EDITED BY

F. A. C. PERRINE, D. Sc., and GEORGE P. LOW.

SUBSCRIPTION PAYABLE IN ADVANCE. TERMS—DOMESTIC, ONE DOLLAR PER YEAR; FOREIGN, TWO DOLLARS PER YEAR.
RATES FOR ADVERTISING ARE MODERATE.

PUBLISHED MONTHLY BY GEORGE P. LOW,

Safe Deposit Building, - - - - - - - - San Francisco, Cal.

LONG DISTANCE TELEPHONE, MAIN 5709.

ENTERED AS SECOND-CLASS MATTER AT THE SAN FRANCISCO POSTOFFICE

VOLUME II. MARCH 1896. NUMBER 3

EDITORIAL.

STANDARD WIRING RULES

The convention held in New York for the purpose of drafting a harmonious set of regulations for wiring to be used by the inspectors of electric lighting companies, insurance companies and municipalities should result in two distinct advances in electric installations. In the first place an adoption of the rules which this body shall approve by all of the various authorities who have the right at any time to inspect an installation, should simplify the difficulties attendant upon securing a correct installation of an electric lighting system both for the owner, the engineer and for the electrical contractor, since if these rules are universally accepted the character of the work to be done will be more clearly understood than can be at the present time and there will be less ground for disputes over accidentally and intentionally bad workmanship. At the same time a harmony among inspectors will give more weight to inspections made in any locality and will do away with the present possibility of a piece of work being at the same time accepted by one inspector and condemned by another, with the general result that we will hope to see a more systematic inspection and a more thorough regard paid to rules for installation than is the case at the present time. Inspection now is often a thing to be avoided rather than sought, for the reason that work which has been carefully done and executed in good faith is still likely to be condemned by some one or other of the many inspectors who are all governed by different rules and as a consequence of this condition the owner or engineer depends more upon his own opinion of the method of installation and more upon the honesty of the contractor than he does upon the report of the expert inspector. As a consquence, work is often accepted as satisfactory which would not pass the requirements of any set of rules because the owners are not sufficiently familiar with the dangers incident to unsatisfactory installation. This is true in country districts more often than it is in the cities, although the danger from fire in a country district is often greater than it is in a similar building in a city.

Hardly a house of any pretentions is erected in any country town which is not at the present day wired for the elctric lights even when the future installation of the electric lights is considered only as a possibility depending upon the growth of the town; at the same time these towns do often grow with surprising rapidity and electric lighting is apt to come to meet the growth rather than wait for it. Inspection of such circuits is particularly necessary for the reason that the opportunities for dishonest contractors are multiplied in any such case where expense of installation is the most important item. Such an inspection, however, we can never hope to see until all of those whose opinions are considered as worthy of authority shall unite to choose a set of rules and adopt a common system of inspection.

NOW OR NEVER

In our January number we called the attention of street railway managers to the necessity for combined action in the question of the overhead trolley patent, a warning which derives new emphasis first from a recent decision of the United States Circuit Court granting injunctions against the Billings and Spencer Company and the Kelsey Electric Railway Specialty Company, who have been for some time manufacturing supply parts of the trolley system, and second from the agreement recently reached between the General Electric and Westinghouse Companies regarding patents. The obtaining of these injunctions against two such strong supply firms indicates a disposition to immediately make the most of the recent patent decision and demands some sort of immediate action on the part of electric railway companies in order to forestall still more dangerous movements on the part of the owners of the patents. It is undoubtedly just for the General Electric Company to earn all that it possibly can from the patents which it possesses and it cannot be criticised for obtaining injunctions against those who are infringing in whole or in part, but at the same time we must consider that while the patent will be a very valuable one to it if it obtains the monopoly of the under-running trolley itself, at the present prices for trollies and trolley parts they may, if unopposed, be tempted to not only increase the prices of such machinery beyond that necessary for a reasonable manufacturing profit, but also at the same time attempt to confine the use of the under-running trolley system to roads using only generating and motor apparatus of General Electric or Westinghouse manufacture.

Opposition to such a stand as this on the part of electric railroad managers is a perfectly legitimate operation and the time to contemplate such a position is before the necessary preliminary steps have been taken by the companies named to make such an opposition ineffectual. We can learn something at this time from the history of the incandescent lamp agitation. So long as the able manipulators of the General Electric Company were enabled to disorganize the opposition of the lamp manufacturers and lamp users their legal efforts were attended with an unbroken series of successes in the courts and the lines which they were rapidly drawing round lamp users to compel the exclusive employment of their machinery were only finally destroyed by a combination of three or four lamp companies, which, towards the last, had been reserved for a final attack. The ownership of such vital patents as are now pooled form a powerful commercial weapon and the only shield against it is to be found in a combination of the electric railway people for the purpose of resisting unreasonble demands.

THE USE AND ABUSE OF FUSES

During the past year the question of the relative advantage to be derived from the use of safety fuses and circuit breakers has been so carefully and extensively discussed in the technical journals and before scientific societies that we should expect to be able to find definite information concerning the usefulness of these two methods of protecting circuits stated in a manner so experimentally strong that it will influence the users of these different devices. On examining the state of the art, however, we find that in spite of this extensive study of the subject no conclusions have been drawn which appeal to all men; and to explain the absences of definite conclusions we must examine the methods used in studying the subject for considered conditions. Immediately upon beginning an examination of the various investigations that have been presented bearing upon this subject we will notice that the usage of fuse wires for protecting electric circuits seems to have been materially changed from the purposes to which they were designed by those proportioning them in the early history of the art. When the fuse wire was originally adopted it was intended to protect the conducting wire of the circuit from being overheated, and at that time it was well understood that the fuse could not be expected to protect the machinery installed upon the circuit; in every instance the fuse was adjusted to the carrying capacity of the wire which it was to protect. All of the recent studies of the fuse wire question have turned upon their ability to protect machinery attached to the conducting circuit, and while in the first case the amount of energy passing over the fuse before its temperature reached the melting point determined its size; in the more recent investigations of the fuses the criterion of quality has been assumd to be the value of the current necessary to melt the fuse. Why the extensive experiments that have been performed on the basis of this second hypothesis should have been necessary is an exceedingly difficult question to answer for the reason that any one examining the conditions necessary for raising a given piece of metal to its melting point by the means of the passage of an electric current will at once find that the melting point is a time function of the energy, and in consequence cannot be stated in terms of current. Nothing further than a confirmation of this theoretical deduction has been derived from the experiments performed.

Now let us consider what is the true function of the fuse wire and to what tests fuses should be subjected in order that we may ascertain their value as a means of protection in any electric circuit. The fuse wire is composed of a conducting material just as the circuit itself is composed of conducting material. When a current is sent over the circuit it heats both the fuse wire and the conductor, the amount of heat thus produced being a function of the time and the ultimate temperature of the conducting metal in both cases depending upon the total amount of heat generated and radiated in the given time. Should a greater amount of current be passed both the fuse and the conducting circuit which is to protect are heated more rapidly and attain the given temperature in a shorter space of time. If this given temperature is the melting point of the fuse then at the time the fuse was melted the circuit had attained a certain specified temperature, and that it did not exceed this temperature, whether the fuse was melted slowly with a small current or quickly with a great current. If the safety fuse is tested by a determination of the temperature of the wire it is proposed to protect, the device has been subjected to a proper and rational test, but if the safety fuse is tested by an attempted determination of the amount of current necessary to melt it, we can see from theoretical considerations that the experiment will be inconclusive and that the current necessary for melting the fuse be a function of the time. The fuse, therefore, is an instrument admirably adapted to the protection of a wire circuit against overheating, but is entirely unsuited for the protection of apparatus against excessive current flow. As soon as experimentors will acknowledge these principles and obtain results in accordance with them we shall begin to have a clear understanding upon the subject of safety fuses and approach a basis upon which they may be satisfactorily be chosen.

ACCURATE PHOTOMETRIC MEASUREMENTS

We are presenting in another column a review of the most recent progress in the efforts to obtain a satisfactory standard for the measurement of light. For the benefit of those who make use of any standard in the measurement of candle powers we think it wise to point out more spe-

cifically some of the difficulties encountered in making these measurements. The search for a standard is important not so much on account of the fact that the standard which any experimenter may use for candle power measurements is liable to variation as on account of the fact that the same standard constructed at different times and by different experimenters may vary in value, as for example, Methven screens which are capable of concordant results under any particular set of conditions. Irregularities in measurements made in any particular laboratory are more often due to the construction of the photometer itself or to the personal equation of the eyes of different expermenters using the photometer than to variations in the standard employed. Candle power measurements are important to the central station manager, not so much on account of their absolute accuracy when compared with measurements made in other laboratories as on account of the comparative accuracy obtained in different measurements of lamps to be tested which are performed in the one central station laboratory. If the measurements made at different times upon different lamps give a true comparison of their relative candle powers the central station manager has at his command all the facts necessary for the choice between lamps.

Such comparative measurements can be made if care is taken to use a fairly satisfactory standard installed in a photometer where there are no reflections and operated by one careful observer who is working under conditions which allow him to be undisturbed in his measurements. Such a photometer is best obtained by installing the lights to be measured in an open dark room ithout a special photometer box, taking care only that direct light shall never fall upon the eye of the operator; the adjustments of flames and lamps being performed by an assistant. This dark room must be free from noise, from vibration and must be supplied with pure air since all of these things are experimentally proven to produce inaccuracy. The ordinary portable photometers which are sold by instrument makers are especially inaccurate mainly on account of the fact that they have serious internal reflections and allow the eye of the operator to be continually subjected to daylight. However convenient it may be to carry a photometer from place to place to examine lights upon the particular circuits where they are running, such observations can only be considered as the roughest sort of approximations to the true results and not at all comparable in accuracy to measurements made at the same voltages in a well installed dark-room photometer.

The installation of an accurate photometer is an important matter in central station equipment since it enables the closest sort of buying of high efficiency lamps while at the same time its inaccurate installation will be a continual source of annoyance.

THE PATENT SITUATION

It was announced on March 12th that final arrangements had been effected between the Westinghouse and General Electric Companies for a common exploitation of their many patents and the future avoidance of useless and expensive patent litigation. Such an arrangement naturally calls to mind a similar agreement between the Edison and Thomson-Houston Companies which finally resulted in the consolidation which brought forth the General Electric Company, and we naturally enquire whether this agreement does not precede a still more gigantic consolidation. A few years ago such a consolidation, would have meant an electrical trust controlling the entire electrical manufacturing business of the United States, but at the present time these two companies represent a monopoly of the old unbusinesslike methods of electrical exploitation rather than any more dangerous monopoly. Without show, without blast of trumpets, without the exploitation of stock, the Siemens and Halske Electric Company, the Stanley Electric & Manufacturing Company together with the Walker Company have firmly established great houses administered according to business principles and they have for the past three or four years been able to secure some of the most highly coveted contracts let during that period; all this without mentioning the achievements of the strong Fort Wayne Electric Corporation and the numberless smaller manufacturing companies. We can easily see that these three first mentioned houses have eliminated from the electrical business during the past few years many of its most objectionable features and that they have rendered almost impotent even before it was accomplished this most recent great consolidation.

The patent contests that have been carried on during the past twenty years have so often been for mutual benefit rather than ith any idea of the success of one side that the patents have been deprived of much of their power. We may not conclude that the litigation that has disgraced the business in the past will now be carried on against the smaller concerns for many of these patents, so much fought over, had no true original basis beyond the necessity of obtaining a cause for contention in the courts and the very existence of the litigation between the great owners of the patents has been the bugbear which has hindered healthy extension in electrical manufacture rather than the existence of the patents themselves. In some minor cases these companies may own patents which will now be respected as they have not been respected before, but we believe in the main the discontinuance of patent litigation means an acknowledgement of its uselessness, rather than a decision to begin it anew against new competitors, and we should read in the consolidation an understanding of the necessity for strictly business methods to be employed in obtaining future business, a healthy conclusion which has been compelled by the success of honest business houses in the electrical field.

Hydraulics

AN EXPERIENCE IN FLUME CONSTRUCTION.

The rapid development of transmission projects in the West and the frequent occurrence of obstacles that are generally unforseen by all but capable engineers, renders any unusual experience in the development of water power or transmission plants of value, and as a result the peculiar experience of the Kings River Lumber Company in its attempt to carry a water flume across a suspension bridge over the Kings River in Fresno County, Califoria, is of interest.

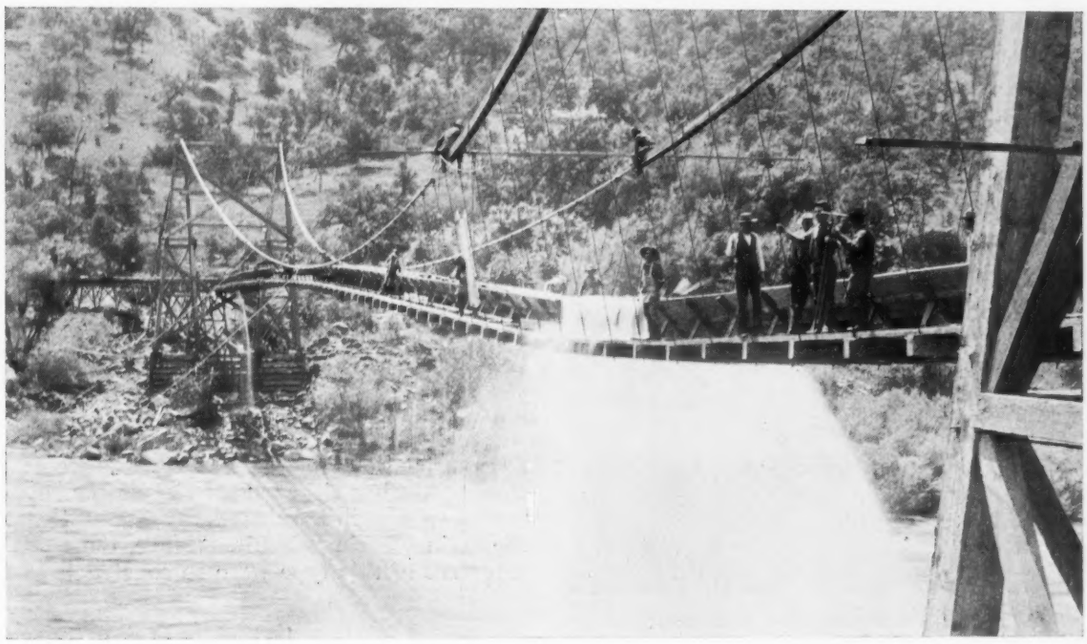


FIGURE 1—AN EXPERIENCE IN FLUME CONSTRUCTION.

As shown in the accompanying illustrations this flume is of V-shaped section, is fifty-two miles in length and at some places has a grade of nearly 23 per cent for about 1,000 yards, giving a total fall of nearly 750 feet. In this connection it is somewhat surprising to learn that in addition to transporting lumber the flume carries passengers and freight in a boat that is a V-shaped box about sixteen feet long and which is roughly knocked together with boards, since it is "good for one trip only." The front end is left off as the velocity of the water is such that it will not run back into the boat. A plank is placed along the bottom, on which the passengers rest their feet while sitting single file on cross seats. When all is ready the spikes by which the boat is held while loading are pulled out and away it goes on its fifty-two-miles journey, in some cases attaining the terrific velocity of seventy or more miles per hour.

The feature of particular interest at present in the construction of the flume, however, as described by Mr. F. A. Koetitz, of the Pacific Bridge Company, rests in a curious experiment tried during the erection of the suspension bridge previously referred to. This bridge is 451 feet in length between the towers and is supported by seven $1\frac{3}{8}$-inch steel cables of Roebling manufacture on each side. The bridge has a grade of nearly 1 per cent, and although the Pacific Bridge Company maintained that the flume could not be operated across the bridge successfully without a stiffening truss, the owners, acting upon their own responsibility and in order to reduce the cost of construction, built the flume without stiffening trusses, as shown in Figure 1. The structure appeared in perfect condition before water was turned into the flume, the grade being gradual and the flume having every appearance of being a perfect piece of workmanship, but when the water was let in results ensued which were quite unexpected to the owners, although clearly foreseen by the engineers of the bridge company. When the water was let in at the head it caused a slight deflection in the first half of the bridge raising the other half. This deflection of course caused a rapid increase of water at the point of greatest deflection on account of the shape of the flume until the water banked up sufficiently to overflow, as shown in the illustration. This overflow, however, prevented any further deflection, but instead, a reaction set in, the point of overflow would run slowly over the center, loading the other half of the bridge, thus having a tendency toward equalization of the load, but the momentum of the water would soon over-balance the load, when the first half of the bridge would raise a little, assisted by its reaction, the second half would deflect accordingly; the water would commence to run faster over the center; the area of water would increase rapidly at the lower half and would deflect and act in the same manner as the first half had done with a resultant overflow. This process would be repeated with a continuous wave motion from one end of the bridge to the other, the time of the oscillatory motion for the "round trip" being one minute and forty seconds, and the action would continue ceaselessly until the water was turned off at the head, when, after it had run or

leaked out, the bridge would come back to its normal position.

It is perhaps needless to mention that the owners turned to the Bridge Company for a solution of the difficulty, when a stiffening truss, as shown in Figure 2, was put in, after which not the slightest trouble was experienced, even under heavy concentrated loads, such as those produced when a "boat" crosses the bridge, damming up the water behind it and lowering the water for some distance in front.

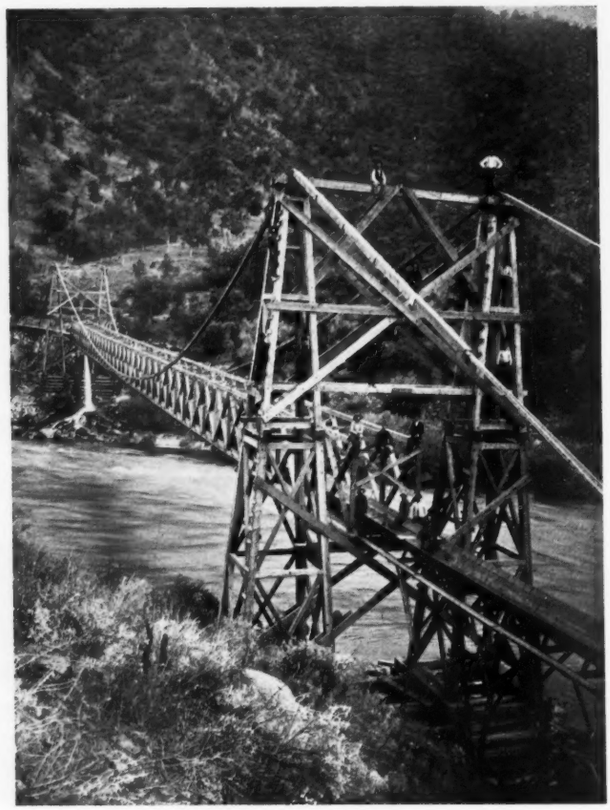


FIGURE 2—AN EXPERIENCE IN FLUME CONSTRUCTION.

The Trade.

In Responding to advertisements in this publication, please mention "The Journal of Electricity."

PROTECTION AGAINST LIGHTNING.

There are few problems in electrical engineering which have presented so many difficulties and at the same time been so successfully solved as that of protecting electrical apparatus against lightning. The skillfully conducted and persistent researches of Mr. A. J. Wurts, of the Westinghouse Electric and Manufacturing Company, in connection with this problem, his discovery of "non-arcing" metals, his successful construction of Non-Arcing Lightning Arresters and the final award to him, by the Franklin Institute of the John Scott Legacy Premium and Medal, are so well known throughout the electrical world as to leave little room for more than a reiteration of the facts concerning the now perfected methods of protection against lightning.

The Non-Arcing Lightning Arresters could not be better described than in the simple and comprehensive language found in the report of the Franklin Institute, from which it is plain that with but few exceptions all

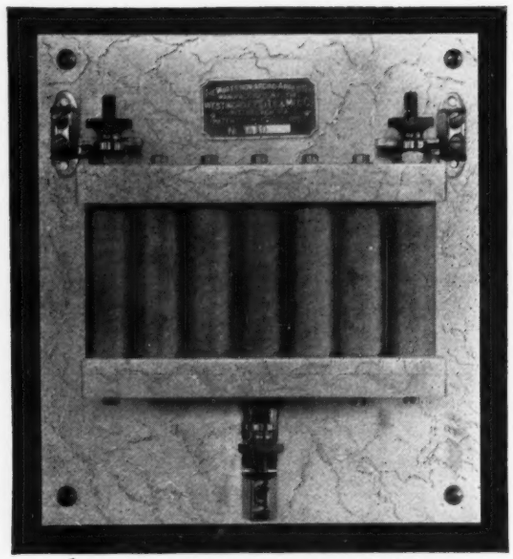


FIGURE 1—Protection Against Lightning.

lightning arresters commonly used, up to the inventions of Mr. Wurts, have been based upon the fact that static discharges generally tend to "ground" by the shortest distance—even when obliged, in order to do this, to jump a considerable "air-gap"—in preference to taking a longer path over a much lower resistance. An arrester of this kind, while often affording a release from the static charge, would also allow the dynamo current to follow upon the arc so produced, thus producing either short circuit or a dangerous "ground," and in both cases causing an interruption of the main working circuit. Hence, the more improved arresters of this type were so constructed as to break

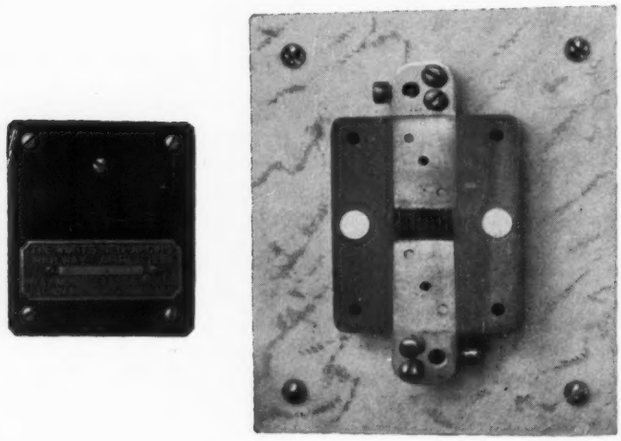


FIGURE 2—Protection Against Lightning.

the dynamo arc as soon as possible. This is easily seen to be a remedy rather than a preventive.

Mr. Wurts perceived this fact and as a result constructed an arrester in which the dynamo arc could not start, rather than one which would break the arc when started, and the "Non-Arcing" Metal Lighting Arrester (Figure 1), although the simplest in construction, is, perhaps, the most notable of all Mr.

Wurts' arresters. It consists simply of seven cylinders of metal, each one inch in diameter, and three inches long, mounted side by side, and separated from one another by one-sixty-fourth of an inch. The central cylinder is joined to ground, and the two outside ones to the two legs of a 1,000-volt circuit. They are knurled on their surfaces, and fixed so that they can individually be rotated upon their axes. When a static discharge takes place, either from one side to ground or from both sides simultaneously, it is found that the flash is instantaneous, and is not followed by an arc, while the temporary change in current value in the main circuit is too small to be easily appreciable. After-examination of the cylinders exhibits a slight black pit or burn where the discharge has passed, and it has been found that this non-arcing property is confined to certain particular metals and combinations of these metals. The most common are zinc and antimony, with which it is impossible to start and continue an arc when they are separated by an air-gap of about one-sixty-fourth of an inch. With longer gaps, e. g., half an inch, vicious arcing is said to occur —a most peculiar fact. Various explanations are offered to account for this non-arcing property, the one most generally adopted being that the metals immediately produce a non-conducting oxide vapor, over which the current cannot pass.

The non-arcing arrester just described is not suitable for any but alternating circuits. For electric railway circuits a different arrester, as shown in Figure 2, has therefore been devised. This consists essentially of a spark-gap, joined by a non-inductive high resistance, made of charred wood. A cover is then placed on the arrangement, and acts as a suppressor of any conducting vapor which might tend to be produced upon discharges taking place. The high resistance, or more properly, the conducting film between the electrodes, seems to act as a wedge through the dielectric, and over which discharges pass disruptively to earth, making a sharp sound, similar to the crack of a teamster's whip. An arrester of this type submitted to the committee of the Franklin Institute, and said to have been struck several hundred times, has suffered but littl damage.

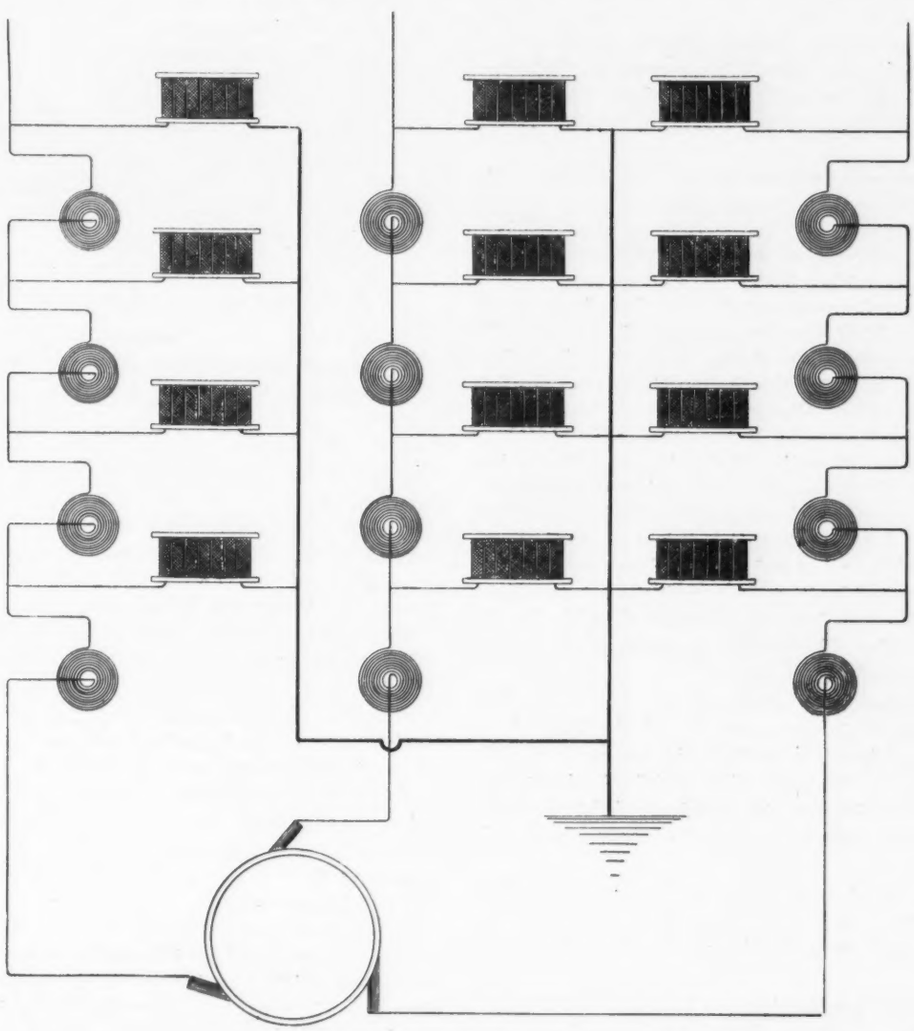


FIGURE 3—PROTECTION AGAINST LIGHTNING.

A lightning arrester connected in the neighborhood of a motor or generator does not necessarily protect that apparatus. If the insulation of the appartus be weak or defective, the apparatus is quite as likely to protect the lightning arrester as the lightning arrester is to protect the apparatus. If the lightning arrester is to protect, the insulation must be sound and of a definite strength.

And yet with even the best of insulation a lightning arrester does not always protect. The reason for this is

not obvious. That which we see and call a lightning flash is not a simple passage from a cloud to the earth; it is a vibration. The lightning oscillates back and forth. The oscillatory character of lightning and of disruptive discharges in general, gives rise to complicated phenomena. Electric oscillations, or waves, interfere with one another much as water waves do. If a trough of water be raised at one end and then quickly lowered, the water in the trough will quietly surge back and forth. If the end of the trough be raised a second time a new system of surging may be started in such a manner that the two will interefere with each other and cause splashing at certain points where crests of the two systems combine to form higher crests. Calm or smooth surfaces will be noticed at points where the crest of one system has been neutralized by a trough of the other system.

In electric wires we have somewhat analagous conditions during thunder storms; we have what a sailor would call a choppy sea. The calm places and splashing places are very close together, so that (and now we come to the point we are looking for) a lightning arrester, for aught we know, may be connected at a calm place, or at a splashing place. If at the former, no discharge will take place at the arrester and the apparatus is liable to become damaged. If at the latter, however, a discharge will take pace and the apparatus will be protected. But these splashing places are constantly shifting their positions. How, then, is a lightning arrester to be properly located? Answer—By connecting such a number of lightning arresters along the line that several of them are likely to be found at splashing places. Possibly arresters which are at splashing places on one occasion may or may not be found at such places on some other occasion. The number of arresters should, therefore, be such that for all conditions some of them, at least, will be found at splashing places.

The successful operation of lighting arresters depends upon a systematic arrangement of the lightning arresters, or a combination of lightning arresters and choke coils, and upon the care with which the installation is made with reference to short straight ground wires, reliable earth connection and maintenance of these connections.

The protection of electric light and power circuits divides itself under two heads: first, the protection of distributing systems; second, the protection of transmission systems.

The protection of distributing systems is effected by means of lightning arresters distributed at frequent intervals over the system. In suburban and otherwise exposed districts four to the mile of wire are recommended. In city districts two are usually found sufficient. For railway systems ground connection to the rail is preferred.

Power transmission systems do not require line arresters. The points of protection being at the extremities of the system, namely, in the power house and motor stations, a bank of lightning arresters, in combination with choke coils, is installed at each of these points. Such a bank is diagramatically illustrated in Figure 3, which represents one end of a three-wire system. For voltages up to 3,000 volts, four choke coils arranged in series in each wire, with lightning arresters intervening, are recommended. For higher voltages than this special combinations have to be made, according to the general characteristics of the system with reference to the capacity of the generator and the use of raising and lowering transformers.

An installation of this nature is preferably made in a small lightning arrester house, built for the purpose and located with special reference to the location of a ground plate in permanently damp earth. The ground plate is preferably made of tinned copper sheeting, and when buried should be provided, both above and below, with a two-foot layer of crushed coke or charcoal.

Although the season has scarcely opened, the demand for Wurts' Lightning Arresters that is being made on the Westinghouse Electric and Manufacturing Co. bids fair to phenomenal. How popular this lighning arrester has become, and how well it has proved its efficiency, may be gathered from the fact that during 1894 the Westinghouse Company sold nine thousand arresters, and in 1895, twelve thousand, while every indication for the present year promises to double the sales of last year.

NEW RAILWAY SUPPLY AGENCIES.

In view of the fact that Abner Doble Co. is now installing some of the largest railway generators on the Pacific coast, it was with considerable satisfaction that the following communication was received from the Detroit Railway Co., concerning four multi-polar direct connected generators, two being 400 kw., and two of 800 kw., and all being built by the Walker Manufacturing Co. After stating that the company is more than pleased with the results obtained from these machines, the letter continues: "Early in the winter when we were extremely short of power, and had but the 2-400 kw. machines available, on several occasions we ran these machines for upwards of ten hours with a 50 per cent. overload, with absolutely no sparking or other injurious effects. On one occasion we carried 1400 amperes at 550 volts on each of these machines for four hours. We have not as yet had occasion to overload the large machines to this extent, but we have every reason to believe from their present operating that they would act equally as well under similar circumstances.

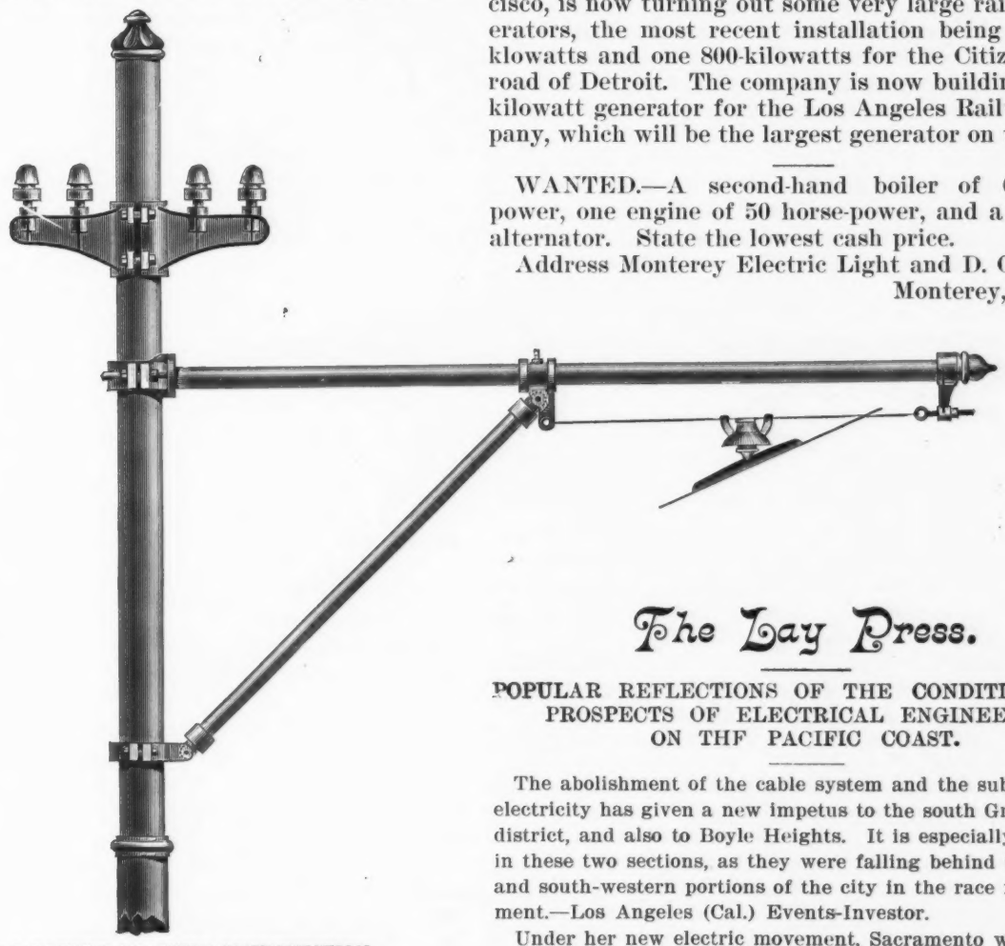
"These four generators have now been running upwards of two months without the removing of a single brush and with absolutely no repairs to the commutator or other parts, with the exception of ordinary cleaning. With a full load on these machines are absolutely sparkless, and the fact of our placing with you an order for two more of the 800 kw. generators is sufficient proof that we are thoroughly satisfied with your apparatus. Owing to the liberal brush contact on commutator one unusual result is obtained, namely, that the commutator is the coolest of any of the working parts of the machine after a long and heavy run."

Messrs. J. W. Brooks & Co. are finding a most gratifying demand for the flexible conduit made by the American Circular Loom Company, for which they are sole Western agents. Contractors and constructors are beginning to appreciate the ease with which it is run, as there is no necessity for joints, elbows, etc., because it may be run an entire length and its tightness is not dependant on the nicety of the fittings of a number of joints, or the carefulness of the constructor.

The firm is also carrying a full line of all material

necessary for bell and annunciator work, and are finding a ready demand for the same. Their Iron Box Bell is meeting with favor beyond all expectation.

An evidence establishing the fact that Eastern concerns of prominence are beginning to realize the promising field which the Pacific coast offers to those who will avail themselves of it, is found in the large number of well-established Eastern concerns which have of late secured branch office establishing Pacific



MORRIS & TASKER BRACKET CONSTRUCTION.

coast agencies in San Francisco. Among these concerns may be named the old reliable house of Morris, Tasker & Co., which was established in 1821 in Philadelphia, and which has since that time built up an enormous business in the line of iron founders, gas engineers and machinists. Its mills are at Newcastle, Delaware and Philadelphia, and the general superiorits of its wrought iron pipe and fittings has resulted in enabling the concern to bring out a recent line of electric railway equipments of a quality surpassed by none. This house has selected as its Pacific coast agency, the Abner Doble Co., itself an old concern having been established in 1859, and which is now prepared to deliver Morris-Tasker materials in any quantity on short notice. Among these materials may be mentioned iron pipe and wood poles, flexible pipe brackets and all regular standard overhead material. These brackets are peculiarly original in that they support a span wire, hitherto accomplished only in the ordinary standard pole construction and which thus gives in bracket construction all the flexibility of double pole construction. In addition to these brackets, which are adjustible, Morris, Tasker & Co. are the makers of the Philadelphia Standard Trolley Pole, the heaviest of which will safely carry a span wire strain of 7000 pounds. Special attention is also given to iron and steel poles for telephone, telegraph, electric light and power uses.

The Walker Manufacturing Company, which has recently placed its Pacific Coast business under the management of the Abner Doble Company of San Francisco, is now turning out some very large railway generators, the most recent installation being two 400-klowatts and one 800-kilowatts for the Citizens' Railroad of Detroit. The company is now building an 800-kilowatt generator for the Los Angeles Railway Company, which will be the largest generator on the Coast.

WANTED.—A second-hand boiler of 60 horse-power, one engine of 50 horse-power, and a 500 light alternator. State the lowest cash price.
Address Monterey Electric Light and D. Co.
Monterey, Cal.

The Lay Press.

POPULAR REFLECTIONS OF THE CONDITIONS AND PROSPECTS OF ELECTRICAL ENGINEERING ON THF PACIFIC COAST.

The abolishment of the cable system and the substitution of electricity has given a new impetus to the south Grand avenue district, and also to Boyle Heights. It is especially noticeable in these two sections, as they were falling behind the western and south-western portions of the city in the race for development.—Los Angeles (Cal.) Events-Investor.

Under her new electric movement, Sacramento will soon become something more than the city of the Capitol, and develop a civic life in which the Capitol will be only a sideshow—San Francisco Call.

Unless all signs fail the growth of Santa Rosa is to be marked in the next twelve months. There is a large area of fertile country extending in all directions from the county seat, the population of which must ever look to this city as its base of supply, wholesale distribution point and chief market for the product of orchard and farm. Business men see plainly that as rapid suburban transit; there will also be a steady growth of manufacturing enterprises requiring cheap motive power. In whatever aspect the problem is viewed, it becomes apparent that the proposed scheme of cheap motive power is the key to success. We are only on the threshold of the development of electrical energy generated by water power, and Big Sulphur creek, which runs from behind the Mayacmas range of mountains into the Russian river at Cloverdale, has a fall and volume sufficient to furnish all the power necessary to supply Santa Rosa and intermediate cities with all the electric light and power they may need. Capital will here find a good opening for profitable investment, and we are informed that certain capitalists in Oakland are already looking into this matter with a view to development along this line.—Santa Rosa (Cal.) Democrat.

This is certainly the age of electricity for light, heat and power. From all directions comes the news of the diversion of water falls for the purpose of furnishing the power for electric appliances for dynamos. The power thus generated can easily be transmitted by wire to a great distance at a loss of only one-half of one per cent per mile. Sacramento operates its electric cars, and is furnished with power for other purposes, from the water flowing over the dam across the American river at Folsom. Fresno is installing a system over thirty miles from that city. Mariposa county is installing a plant for the purpose of running the extensive mining machinery in that county. This county alone seems to be backward in taking advantage of the opportunities offered. The water flowing over the dam at La Grange has been estimated, by competent authorities, to be sufficient to furnish from 5,000 to 8,000 horse power. This amount of power would be sufficient to turn every wheel in this valley from Fresno to Stockton. * * * Those towns located near mountain streams all along the foothill districts, could no doubt make use of the streams falling down the mountain sides to produce electric power adequate to all their needs at much less cost than is now required for but a small part of the conveniences which cheap electric power makes possible. There is a wide field in the development of cheap electric power by means of the water wheel, and the distribution of it at small cost to the people of neighboring cities, towns, villages and farms.—Modesto (Cal.) News.

The entire talent of Bernal Heights was recently invited to an entertainment given in honor of the coming of age of Terrence Flannigan's daughter. Nothing was left undone that could be devised to make every one feel at home and happy. The Misses McManus, who have more than a locality reputation as vocalists, were present, but the star of the evening was Professor McNally, who had been making some experiments with the cathode ray. The Professor had brought his apparatus with him and a feast of reason was anticipated.

Phil. Burns' billy goat was tethered in the back yard, and occasionally the horns could be heard as it tried to pry clapboards off the back of the house.

About 11 o'clock Mr. Terrence Flannigan called for attention and announced that Professor McNally would now give an exhibition connected with his latest discoveries in the field of science. Mr. Philly Burns had consented that some experiments should be tried with his goat.

The announcement caused a hum of general approval, and after a few preliminaries the goat was led in. In order to keep the animal quiet, Professor McNally said it would be necessary to administer an anesthetic. This was done and the goat became at once a fit subject for investigation.

It is not in the memory of man that a social gathering at Bernal Heights was ever so electrified before.

" 'Fore heaven," said McNally, as the interior of the goat began to be revealed.

"Mother of Moses," murmured Miss Flannigan.

Distributed throughout the goat's anatomy were a watch and chain, a tooth brush, a razor, half opened, a corkscrew, a child's shoe, one undigested raw turnip, a small pewter mug, a soft rubber ball and a wooden peg.

"Get out a search warrant," demanded Mr. Casey, who had lost the watch and chain.

"Dissect the craythur," lisped Miss McManus.

Mr. Philly Burns pushed the crowd aside and took up the goat to carry it out. A small roit took place, and when it was over the goat was found to be dead. Mr. Philly Burns now threatens a suit for damages against Professor McNally for killing the goat with anesthetics, buh McNally smiles skeptically and says that the articles revealed by his Roentgen ray experiments were enough to have caused Billy's death eventually. Mr. Flannigan is blamed for turning a coming-of-age party into a scientific expose. In fact, the chilliness caused by the affair has settled like a frost over Bernal Heights.—San Francisco Examiner.

Personal

Mr. C. P. Gilbert, Manager of the Detroit Edison Company, is as usual "summering" the winter in California, and is at present in San Francisco.

Mr. J. W. Godfrey, known the country over as "Genial Jim, of Habishaw wire fame," is again on the Coast, and is at present at the Palace Hotel, San Francisco.

Mr. J. C. Pierson, for many years Superintendent of the Capital Gas Company of Sacramento, has resigned, and Mr. George W. Jackson has been promoted to the vacancy.

Mr. John Martin, Pacific Coast agent of the Stanley Electric Manufacturing Company, and who has been East for the past month, is expected to return about Aphil 15th.

Mr. J. F. Gray, Secretary of the Mechanical and Electrical Departments of the late World's Columbian Exposition, and more recently of the Atlanta Exposition, is touring California.

Mr. E. C. Sharp, Consulting Engineer for the cities of Riverside and Colton, has been in San Francisco for a fortnight on business connected with the municipal transmission and lighting plant of Riverside.

Mr. George Bole, Manager of the Pittsburg office of the Babcock & Wilcox Company, is in San Francisco, and will visit various points of interest on the Coast in quest of rest and recreation.

Mr. L. B. Pemberton, of late associated with the Fort Wayne Electric Corporation, has assumed the Southern California agency of the General Electric Company, with offices at 225 West Second street, Los Angeles.

Mr. John A. Britton, Secretary of the Oakland (Cal.) Gas, Light & Heat Company, is now in the East, presumably for the purpose of looking up machinery for the rebuilding of the Berkeley Electric Light Company, in which he is heavily interested.

Mr. E. E. Stark, of the electrical engineering staff of the Stanley Electric Manufacturing Company, has completed the installation of the power transmission plant of the Nevada County Electric Power Company, and is at present in San Francisco with headquarters at the offices of the Stanley Company at 106 Market street.

Mr. W. J. Barrett, Los Angeles representative of the John A. Roebling's Sons Company, was among the recent visitors of San Francisco. Mr. Barrett is one of the "Committee of Thirty" of the coming Fiesta in the Southern metropolis, and was warm in his assurances that those of the electrical fraternity who attend the carnival will find him to be "the bureau of information for Southern California."

Obituary

William F. Atwater, late senior member of the pioneer independent railway supply house of Reger & Atwater, died in San Francisco on March 30th, after a brief illness, of typhoid-pneumonia. Having the fortunate faculty of blending geniality and business shrewdness most agreeably, it was mainly through his efforts that the firm won a wide popularity, which can hardly be otherwise than enduring. It is announced by the executors of the estate that Mr. Atwater's interest in the business will still be maintained, and that both the firm name and its location will remain unchanged.

It is with deep regret that announcement is made of the death of Mr. Nat. W. Pratt, at his home in Brooklyn, N. Y., on March 10th, and in his demise the mechanical engineering world, while losing one of its shining lights, revers the memory of his genius to which is largely due the development of

the Babcock & Wilcox boiler. Indeed, the world-wide fame of this appliance is his best monument. Born of stanch old New England families, which settled in Plymouth county, Mass., in 1630, he inherited mechanical tastes from his father, William Pratt, who was Superintendent of the Burnside Armories at Providence, R. I., during the war, and to the energy, engineering ability and remarkable business qualifications of the son is alone due his rising from humble beginnings to the presidency of the great Babcock & Wilcox Company. Mr. Pratt was noted not only for his sound business judgment and remarkable energy, but also for his generosity and kindness of heart. Even his business opponents admired him for his singular aggressiveness as applied to business, and by all with whom he came in contact, both at home and in trade, he was universally loved and admired.

Reports of the Month.

LITIGATION.

San Leandro, Cal.—Judge Ogden of the Superior Court has overruled the demurrer of the city of San Leandro in the action brought by J. A. Hammond to prevent the sale of the $10,000 electric light bond issue.

Santa Cruz, Cal.—Owing to the purchase of the stock of the plaintiffs ,the various suits of F. W. Swanton et. al., against the Electric Light & Power Company, have been dismissed, with one exception, viz.: that of Swanton to recover $12,000 alleged to be due.

Tacoma, Wash.—The suit of the Tacoma Railway & Motor Company and P. D. Armour Jr. and J. O. Armour, of Chicago, against the New York Guaranty and Indemnity Company, Trustees, and which will soon come to trial in the Federal Court here, promises to be very sensational. It is averred that the late Paul Schultz fraudulently transferred stock and bonds of the Tacoma Railway & Motor Company to the amount of $746,000 to the General Electric Company, the Northwest Thomson-Houston Electric Company and kindred companies, which amount was in excess of the value received by the Tacoma Company for electrical apparatus and other equipment.

TRANSPORTATION.

Lompoc, Cal.—George H. Long is advocating an electric road.

Gastroville, Cal.—An electric railroad from the depot at Moss Landing is being discussed.

Stockton, Cal.—An electric launch will make its appearance on the Stockton channel and lakes this summer.

Pomona, Cal.—The Orange Grove Street Railroad Company, in a communication presented to the City Trustees, stated it is figuring on operating a line of storage battery cars.

Tucson, Ariz.—C. F. Hoff's application for an electric railway franchise has been granted upon condition that the work be begun within 90 days, and be finished to the University within one year.

Sonora, Cal.—Colonel N. W. Griswold of Kenwood is authority for the statement that an electric road will be built from Santa Rosa to Sonoma and, when completed, will carry passengers at the low rate of 1 cent a mile.

Mill Valley, Cal.—The grading of the roadbed for the Mount Tamalpais Scenic Railway is being vigorously prosecuted, and contracts have been awarded to the Risdon Iron Works for engines and boilers. "G. E. 1200" equipments are to be used.

San Bernardino, Cal.—W. B. Taylor, of Toledo, O., is at the head of a syndicate that is contemplating the purchase of the Kansas City tract, and if this is done an electric road will be built, making a circuit of the valley within the Santa Fe loop.

Fortuna, Cal.—F. Nelson, proprietor of the electric light works of Ferndale, states that an electric railroad will be built this summer between Fort Kenyon and Fortuna by himself and four San Francisco associates, provided the necessary franchises and rights-of-way can be secured.

City of Mexico, Mexico.—H. C. Butler, representing an English syndicate, has purchased the street-car systems of the entire city, the price paid being reputed to be about $7,500,000. The new company has already taken charge of the system, and it is stated will spend $12,500,000 more in equipping the system with electricity and making many other needed improvements.

Sacramento, Cal.—L. T. Hatfield, President of the Sacramento, Fair Oaks and Orange Vale Railway, has issued an open letter to the public to the effect that local indifference would cause an abandonment of the project, whereupon a citizens' committee was appointed to canvass the city for subscriptions, and there is every reason to believe now that Sacramento will subscribe to one-quarter of the bonds as required.

San Diego, Cal.—The endeavor to sell the San Diego cable road at its appraised valuation, $121,500, failed, and that figure was reduced by the auctioneer until $55,000 was reached, below which he would not go. It is stated that, since then, five citizens of this place have agreed to take four-fifths of the road at $45,000, the owner, George B. Kerper, retaining one-fifth, for the purpose of converting it into an electric line at once.

Belvedere, Cal.—It is stated that the Belvedere Land & Water Company will build an electric railway from San Rafael to this place to be operated in conjunction with a ferry to San Francisco. This action is believed to be determined upon should the consolidation between the North Pacific Coast Railroad Company and the San Francisco & North Pacific Railroad Company result in the abandonment of the ferry service to Tiburon, as is intimated.

Riverside, Cal.—The Riverside & Arlington Street Railway Company has applied for an extension of its franchise on Main street and down the valley to Arlington, on the ground that under the present 20-year franchise it is impossible to borrow money, but by extending the time to 50 years money could be secured with which to construct an electric road.

Elmhurst, Cal.—Since the reconstruction of portions of its main line, the Oakland, San Leandro & Haywards Electric Railway has been considering the advisability of entering into more serious competition with the Southern Pacific trains by increasing the speed of its through cars, and accordingly has equipped car No. 20 with two motors, which, under trial, have developed a speed of 42 miles an hour. The experiment was so successful that it is probable that several such cars will be put on shortly between Haywards and Oakland.

Oakland, Cal.—The California Railway, a standard steam road extending from Fruitvale to Laundry Farm, is to be converted into an electric line, and operated in conjunction with the Alameda, Oakland & Piedmont Electric Railway Company. General Electric equipment is to be used, and the Nantasket trolley wire of the John A. Roebling's Sons Company has been purchased for the new line. This wire has an area of 330,000 circular miles.——The Oakland Consolidated Street Railway Company contemplates extending its cemetery branch westward to Shell Mound Park, and the Oakland Trotting Park; the improvements, if made, will cost $25,000.

San Francisco.—The John A. Roebling's Sons Company has sold a complete suit of cable to the Sutter-street system, comprising in all 28,150 feet of 1⅛-inch rope and 36,000 feet of 1¼-inch rope.——Owing to an error in advertising, the sale of the San Francisco and San Mateo electric road has been again deferred. It is said that the road will now bring at public sale

more than 25 cents on the dollar. There is outstanding about $1,100,000 in bonds, the principal holders being C. C. Butler, $400,000; Buck & Olden, $400,000, and two of the Spreckels family, $152,000. It is believed that the bondholders will put in the road, although the Market-Street Railway Company is thought to be desirous of securing it, despite denials that have been given.

Los Angeles, Cal.—An electric line between Los Angeles and Long Beach is under consideration.——The Pasadena and Los Angeles Electric Railway Company is pushing the construction of its new Macy-street line in order to give it an entrance into the center of the city over its own tracks rather than upon the tracks of the Los Angeles Railway Company. W. H. Workman and others have applied for an electric railway franchise, running through various streets from Third street and Stevenson avenue to the intersection of Fourth street with the eastern limits of the city in Boyle Heights. It is hoped to have the road in operation before November.——The Orange Grove Street Railway Company has applied for a franchise from the Park to the cemetery.

San Jose, Cal.—Local capitalists have guaranteed the $50,000 bonus demanded by the Eastern syndicate before building the proposed electric road from this city to Saratoga and Congress Springs. The application for a county franchise is now before the Supervisors, and will be granted shortly, but as it is necessary to advertise the sale of the city franchise for six months the construction will hardly begin in earnest before next fall, and in the meantime it is probable that the machinery and equipment will be purchased and sent out from the East via Cape Horn.——J. J. Scrivner, President of the reorganized Alum Rock Railway Company, has been given until April 9th to make a definite proposition to the Board of Supervisors concerning the intentions of the company regarding the abatement of the steam dummies on the Alum Rock line. It is intimated that if the company does not equip the road electrically, its franchise will be revoked.

INCORPORATION

Tucson, Arizona.—United States Refuse Purifying Company. Capital stock, $500,000. Object: To treat waste material and manufacture illuminating and fuel gas.

Roslyn, Wash.—Roslyn Electric Light Company. Capital stock, $10,000. Object: To supply electric light and gas. Promoters, Donald Thiery, L. E. Sallady.

Tacoma, Wash.—The Bowie-Love Company. Object: To deal in electrical goods, apparatus and supplies. Capital stock, $1,000. Incorporators, C. S. Bowie, M. M. Bowie and William J. Love.

Long Beach, Cal.—The Long Beach & San Pedro Electrical Company. Capital stock, $50,000. Directors, I. E. and E. S. Tutt and Charles C. Glass, of Long Beach, J. H. Braley of Los Angeles, and W. M. Glass of Pasadena.

Los Angeles, Cal.—The Gas Consumers' Protective Association. Capital stock, $25,000. Object: To construct gas and electric light plants. Promoters, W. H. Smith, George C. Rockwell, A. C. Harper, Albert Lindley, W. D. Newell.

Butte, Mont.—The Montana Electric-Gas Company. Capital stock, $25,000. To manufacture and exploit calcium carbide and acetylene. Promoters, T. T. Baker, James H. Monteath and John P. Forbes, of Butte; J. S. M. Neill, George F. Cope and A. J. Davidson of Helena, et. al.

Tacoma, Wash.—The Puget Sound, Mount Vernon, Tacoma & Eastern Railway Company. Capital stock, $2,000,000. Object: To do a general railway, telegraph, telephone and electric light business. Promoters, G. L. Holmes, P. B. Ceasar, L. R. Manning, I. W. Anderson, T. W. Enos, W. C. Wheeler.

Los Angeles, Cal.—It is announced that the Metropolitan Gas Company will soon be incorporated with George H. Bonebrake, A. Jacoby, W. J. Washburn, M. T. Allen, Datus, C. Smith and Henry C. Rew as incorporators, and it is stated that the new company will offer to reduce the present price of $1.90 to $1.35.

San Diego, Cal.—The Bailey Triple Ledge Gold Mining Company; to construct highways, railroads, electric, steam or other motive power and chutes to and from mines. Capital stock, $100,000. L. H. Bailey, Banner, A. C. Mason and O. C. Drauga, of San Diego; E. A. Stanley, of Julian; and James A. Jasper, of Ramona, Cal.

San Francisco, Cal.—The Sterling Electric Supply Company. Capital stock, $100,000, of which $10,000 is subscribed. Incorporators, John R. Cole, O. H. Pennoyer, F. G. Cartwright, F. W. Gale and F. M. Delano.——The Central Development Company, Capital stock, $25,000. Objects: The construction of electric, steam and water plants, etc. Promoters, H. B. Havens, Thomas S. Fish, William C. Staptford, A. K. Durbrow and J. Staptford Jr.

Salt Lake City, Utah.—The Pioneer Electric Power Company. Capital stock, $2,000,000. Officers: President, George Q. Cannon; Vice-President, John R. Winder; Secretary and Treasurer, C. K. Bannister, and they, together with the following, constitute the Board of Directors: Joseph F. Smith, Wilford Woodruff, A. B. Patton, Frank J. Cannon, A. H. Woodruff, F. D. Richards.

Bingham, Utah.—The Bingham Electric Light & Power Company. Capital stock, $250,000. Object: To construct a light and power plant and furnish light and power in the West Mountain mining district, Salt Lake county. The officers and trustees are Frank K. Gillespie, President; O. B. Hardy, Vice-President; James Moffat, Treasurer and Secretary. The company succeeds to the franchise granted O. B. Hardy and W. J. Morehead by the county over public roads for erecting poles, stringing wires, etc.

Spokane, Wash.—The Spokane & Columbia Telephone & Telegraph Company. Capital stock, $75,000. Incorporators, Angus McNish, of Rossland, B. C.; and N. R. Stone, L. Frank Gordon, Jay H. Adams and John D. Farrell, of Spokane. Object: To construct, etc., telephone and telegraph lines in the United States and British Columbia.——The Helen Gold Mining Company. Capital stock, $600,000. Objects: To engage in general mining and electric light business. Incorporators, T. D. Rockwell, W. J. Collins, W. C. Drury, J. C. Haas, W. J. C. Wakefield, Andy Simons and Charles Dawson.

TRANSMISSION.

Salt Lake City, Utah.—The Big Cottonwood plant is to be started on April 15th.

Logan, Utah.—The Hercules Electric Power Company is erecting its pole line between Logan and Hyrum via Providence and Melville.

Los Angeles, Cal.—Wybro & Lawrence have contracted for the placing of two high-speed Sprague-Pratt passenger elevators in the new Wilcox Block.

Mokelumne Hill, Cal.—The Roanoke Mining Company will install its lighting and power plant as soon as the weather will permit. This town will also be lighted therefrom.

Pomona, Cal.—The San Antonio Electric Light & Power Company expects to have non-synchronous, single-phase alternating current motors in operation in this city shortly.

Grass Valley, Cal.—Superintendent Treadwell of the Red Hill mine states that electricity will be used as the motive power in the new mill now under contract to be erected.

Valparaiso, Chili.—Saavadera Penard has ordered two 81-inch Pelton water wheels, each delivering 310 h. p., and to ope-

rate under a head of 364 feet, to be used in an electrical transmission plant he is about to install.

Bingham, Utah.—The power for the operation of the recently incorporated Bingham plant is to be obtained through the Gillespie water right at Big Cottonwood, and electric power is being contracted for delivery to the mines hereabout before next fall.

Twin Bridges, Mont.—Denver and Telluride capitalists are considering the advisability of erecting a big electric power transmission plant to be operated from the water power of Madison river for the purpose of working the gold mines in the northern and eastern parts of Madison county.

Ogden, Utah.—C. K. Bannister is authority for the statement that President Bannigan of the Consolidated Rubber Company of Providence, R. I., has agreed to purchase bonds of the Pioneer Electrical Power Company to the extent of $1,500,000. The contract with Mr. Bannigan has been closed, and under it it is agreed that the plant shall be in operation by December 1, 1897.

Oakdale, Cal.—The Stanislaus Milling and Power Company is this week placing poles and wires by which electricity will be transmitted to Oakdale for power and lighting purposes. The power is obtained by water pressure at Knight's Ferry, 13 miles distant, and is more than sufficient to supply Knight's Ferry and Oakdale. Eventually the wire will be continued to Modesto.

Napa, Cal.—George I. Husmann points out in a communication to the Register that 13 miles distant there is a fall of 300 feet in Rector Creek, and that 15 miles beyond the Sage and Chiles Creeks furnish abundant water at a fall of 300 to 400 feet, suggesting that these water powers are suitably located for power-houses to operate an electric railway that would open up a most productive region.

Colorado Springs, Col.—Wilson & Jackson, of Chicago, who hold the contract for boring a tunnel for an extension of the city waterworks, have ordered the equipment for a temporary transmission plant, consisting of a 3-foot Pelton water wheel operating at 600 r. p. m. under a 600-foot head, and which will drive a 150 kw. 12-pole General Electric 3-phase generator. This plant will be located at the foot of the mountain to be tunneled, and circuits are to be run thence to each end of the tunnel where air compressors will be operated for drills, etc.

Fresno, Cal.—A. L. Fish, of San Francisco, is erecting a Root rotary pump in the Fresno waterworks, which will be run by a 75 h. p. induction motor, to be operated by the San Joaquin Electric Company. This pump will have a capacity of 4,000,000 gallons daily.——The San Joaquin Electric Company is making satisfactory progress in the installation of its plant. The power-house and substation buildings have been completed; the receiver and Pelton water wheel and dynamos are in place, and the machinery is being set up in the substation building, and although the company was incorporated only on April 2, 1895, it is believed that the plant will be in operation within 13 months from the time of its conception.

Riverside, Cal.—The contract awarded by the city of Riverside to the California Electrical Works of San Francisco for the installation of the municipal transmission and lighting plant provides for taking power from the 3-phase generators at the power plant of the Redlands Electric Light & Power Company on Mill Creek. The station is eight miles distant from Redlands and 21.98 miles from Riverside by pole line measurement. The generator is to deliver 3-phase current at 2,500 volts to a bank of special step-up transformers to be built by the Wagner Electrical Manufacturing Company, in which the e. m. f. will be raised to 11,000 volts. Three transformers, each of 100 kw. capacity, are insulated with oil and cooled by the circulation of water in three-fourth-inch pipes coiled around the inner case, the whole being closed in cast-iron boxing. By this means the transformer temperature at full load is guaranteed to be confined within 20 per cent of the temperature of the air. From the transformers the current is to be carried as far as Mentone over the pole line of the Redlands Company, whence the transmission circuits will be continued to Roverside over a new line of poles to be built for the city. A single 3-phase transmission circuit will be used consisting of three No. 4 bare copper wires, supported on Fred M. Locke's china insulator and the Locke indestructible steel pins. The transmission loss will be 9¼ per cent at full load. About 1,700 30-foot round cedar poles, 6 inches at the top, will be used, which will be placed 120 feet apart on the transmission line. The butts of the poles are being painted with P. & B. paint, as are also the braced crossarms. From the city limits to First street the the transmission circuits will be continued to Riverside over a inches at the top, thence to the substation on 45-foot poles. Current is to enter the substation at 10,000 volts, where it will be reduced to 2,000 volts, through a bank of three Wagner transformers of the type used at the power-house, except that their total capacity will be 250 kw. From the distributing board are to be run two three-wire circuits for incandescent service and two three-wire circuits for arc lighting service. All lighting, both incandescent and arc, is to be of the constant potential system through transformers stepping down from 2,000 volts to 100 volts, or 50 volts, according to whether incandescent or arc lighting service is used. Helios 14-hour arc lamps are to be used exclusively, and are to be operated from individual transformers, there being 90 street lamps and 10 commercial lamps, in addition to about 1,000 incandescents. The city lighting will consist of 40 arcs on the intersection plan, 25 arcs on the Western Electric mastarms and 25 arcs on pole lines. An experiment is to be made in lighting Magnolia avenue by incandescents, in which 35-foot poles will be placed in the center of the avenue, with brackets, each carrying a cluster of three lights and reflector, there being in all 50 such clusters. There will be about 21 miles of pole line in the city limits.

ILLUMINATION.

Hollister, Cal.—A new engine is being installed in the electric light plant.

Benicia, Cal.—The Solano Electric Company has purchased a 35 kw. Westinghouse alternator.

Grass Valley, Cal.—The Nevada County Electric Power Company is to light the mine of the Providence Mining Company.

Ferndale, Cal.—A. B. Cone has been appointed Superintendent of the electric lighting plant, being installed by F. Nelson.

Bodie, Cal.—Eli Johl is to install an electric lighting plant here, and will probably operate the same by a gasoline engine.

Alvarado, Cal.—The Oakland Water Company is installing a 100-light Westinghouse incandescent plant in its waterworks.

Port Angeles, Wash.—L. D. Stewart has been appointed Manager of the municipal electric light plant.

Carson, Nev.—H. K. Brown has installed a one h. p. Westinghouse incandescent dynamo for lighting his residence.

Coulterville, Cal.—A 60-light Wood bi-polar incandescent mac dynamo has been sold to the Merced Gold Mining Company.

Salem, Or.—An independent turbine is being installed in the Salem Woolen Mills for driving the incandescent lighting generator.

Elko, Nev.—The Elko-Tuscarora Mercantile Company is installing a 15 kw. multipolar 125-volt Westinghouse dynamo for lighting this town.

Honolulu, H. I.—Theodore Hoffman has purchased a 100-light Westinghouse incandescent dynamo, to be installed on a sugar plantation near by.

Oakland Cal.—Charles McClane has been appointed by the Oakland Gas, Light & Heat Company as Superintendent for its Lorin and Berkeley interests.

Placerville, Cal.—The Placerville Electric Light Company contemplates the installation of a large gasoline engine to be used whenever the water supply fails.

San Diego, Cal.—San Diego Gas & Electric Light Company has secured the contract, ending March 31, 1897, for lighting the city with 81 tower lamps and 36 mast-arm lamps.

Palo Alto, Cal.—The Redwood City Electric Company has been awarded a franchise for lighting this place on the condition that the town be fully supplied with lights by April 15th.

San Luis Obispo, Cal.—On March 16th, the stockholders of the San Luis Gas Company elected a Board of Trustees, consisting of H. Brunner, President, and J. K. Prior, J. Barneberg, F. D. Frost and H. J. Edwards.

Long Beach, Cal.—The Long Beach Electric Light Company has secured a contract from the city for erecting 20 arc lights on the wharf. These are to be placed 100 feet apart and burned at a cost of $40 per month.

Watsonville, Cal.—The new steam plant of the Watsonville Electric Light Company is to consist of a 200 h. p. cross compound condensing Buckeye engine for regular service, and two 54-inch by 16-foot return tubular boilers.

Medallin, U. S. C.—One 140 h. p. and one 630 h. p. Pelton water wheels to operate under a head of 150 meters have been ordered of the Pelton Water Wheel Company of San Francisco for use in the municipal electric lighting plant.

Santa Clara, Cal.—It has been definitely determined that the city will own its electric lighting plant, but whether the Santa Clara plant of the Electric Improvement Company of San Jose will be bought, or a new plant installed, is yet unsettled.

Riverside, Cal.—A full description of the municipal electric lighting installation appears elsewhere under "Transmission." ——The Sespe Brownstone Company is installing an electric lighting plant in order to work its quarries day and night.

Nevada City, Cal.—The Nevada County Electric Power Company is endeavoring to secure control or to purchase the electric lighting plants in Nevada City and Grass Valley, and which are owned by K. Casper and John Glasson respectively.

Monterey, Cal.—The Monterey Electric Light and Development Company is in the market for one 60- horse-power boiler, one 50 horse-power engine, and one 500-light alternator, and invites estimates on above for new or second-hand machinery.

Lamiradi, Cal.—The Machinery Supply Company of Los Angeles is installing an isolated plant in the residence of Colonel Robert Northam, comprising a complete steam dynamo and storage battery outfit, together with their refrigerating plant.

Berkeley, Cal.—The Berkeley Electric Light Company is at present running one 88-light, 9.6 ampere Western Electric arc dynamo, and one 1,300-light, 1,040-volt La Roche alternator, while in reserve is held one 60-light Ball arc dynamo and one 500-light La Roche alternator.

Redwood City, Cal.—The Redwood City Electric Company, which has been in operation since January 20th last, has about 600 incandescent lamps wired on its circuits, and will probably have finished all wiring and installation by June 1st. At present its nightly load averages 250 lamps, the price for current being 1 cent per lamp per hour.

Fresno, Cal.—The contract for street lighting for one year from April 15th has been awarded to the San Joaquin Electric Company for $6.95 per lamp per month, all night lighting, which is $3.55 less per lamp than the city is now paying on the 1 o'clock schedule, and the new lamps are to be of 2,000 c. p., while the present ones are of 1,200 c. p. The bid of the Fresno Gas & Electric Light Company for the same service was $6.95.

Pasadena, Cal.—At the annual meeting of the Pasadena Electric Light Company, on March 3d, the Board of Directors for the ensuing year was elected as follows: F. C. Bolt, J. S. Torrance, A. W. Armstrong, L. P. Hansen, L. C. Torrance. The Board of Directors elected its officers as follows: L. C. Torrance, President; L. P. Hansen, Vice-President; J. S. Torrance, Secretary; San Gabriel Valley Bank, Treasurer. It is the intention of the company to make further extensions during the summer upon such streets as may hold out inducements for house-lighting and generally extend their business.

Santa Ana, Cal.—The application of J. Buel for an electric light franchise has revived the question of municipal ownership, which is again being considered by the Board of Trustees. ——C. M. Holmes, President of the Santa Ana Gas & Electric Company has announced a reduction in gas rates, under which the residence rate for cooking and lighting will be $2, and the lighting rate on a scale varying from $3 to $1.50, according to consumption.——George E. Nolan, a Los Angeles electrician, has reported to a committee of the Board of Trustees, by whom he was employed, that the total valuation of the steam, electric and pole line equipment of the Santa Ana Gas & Electric Company is $3,025.

Stockton, Cal.—The Stockton Gas & Electric Company has secured the city lighting contract, terminating August 1, for $11.70 per lamp per month.——The Stockton Gas & Electric Light Company will soon commence boring a new gas well on a corner of Anderson and Pilgrim streets, from which it expects to derive a flow of nearly 100,000 cubic feet of gas per day from a depth of 2,000 feet. Considerable new piping is to be laid to supply the southeastern portion of the city from the new well. The company has a gas well at the intersection of Hunter and North streets, and another at the corner of Fremont and Grant, besides the big Haas well in the western part of the town. All of them are to be connected, which will equalize the pressure throughout the mains.

Los Angeles, Cal.—The West Side Lighting Company, by E. E. Peck, Manager, has bought a 1,000-light Wood alternator and 1,925 lights capacity in Wood transformers. The company's plant, which is situated just outside the city limits, is furnishing arc and incandescent service at the University, Harper tract, etc., and has applied for a franchise that will enable it to engage in city lighting.——The Los Angeles Electric Company has bought a car-load of Westinghouse transformers in assorted sizes.——The Lester F. Scott electric lighting franchises will probably revert to the city on April 28th next, as its owners have thus far failed to fulfill the conditions under which it was granted.——Griffes & Sumner have secured the contract for wiring the Hollenbeck home.

Alameda, Cal.—The supplemental steam plant which A. L. Fish is to place in the municipal lighting station is to consist of a 450 h. p. cross compound Buckeye engine, and four 72-inch return tubular boilers.——John A. Britton, Secretary of the Oakland Gas Company, has written a letter to the City Trustees, in which he emphatically denies that the company or any one connected therewith authorized or suggested the suit which has been brought against the City Trustees to restrain them from improving the municipal electric light plant.—— The City Electrician's report on the municipal lighting plant for February shows the operating expenses to be as follows: Construction account, $60.70; salaries, $412.50; labor, $116.50; running expenses, $115.32; coal oil and waste, $339.60; total, $1,044.32. The income is estimated as follows: Private consumers, $297.55; City of Alameda, $35.35; Free Library, $27; arc lights to city, $750. This leaves a profit to the city of $65.28.

CARBONS!

"THE ELECTRA"

High Grade Nuernberg Carbons

TRADE MARK
Highest award at the World's Columbian Exposition, Chicago, 1893

TRADE MARK
Highest award at the World's Columbian Exposition, Chicago, 1893.

For Direct Current Arc Lamps

FOR Alternating Current Arc Lamps

Are by far the most economical and efficient manufactured. They produce a very brilliant and absolutely steady light.

The leading electric light stations who have tested the "ELECTRA" CARBONS, and have since adopted them exclusively for their arc lighting, admit their superiority over any other high grade carbons.

Send for Latest Price Lists and Samples to **HUGO REISINGER, No. 38 Beaver St., New York.**

Sole Importer for the United States, Canada, etc.

John M. Klein's Electrical Works

HEADQUARTERS FOR

Everything Electrical, Telegraph, Telephone and Electric Light Supplies.

ELECTRICAL ENGINEERING, CONSTRUCTING and MANUFACTURING

Armature Repairing a Specialty. All Work Guaranteed.

AGENTS FOR Fan Motors, Klein & Son's Electrical Tools, "Standard" Terra Cotta Bushings, Klein's Patent Iron Pins and Fixtures, etc.

Agency for the Long Distance "Hunning Dust" Transmitters and Regular Electric Telephones. A whisper over these instruments can be heard 20 miles.

Telephone, Main 389. Correspondence Solicited. Send for Latest Catalogues.

421-23 MONTGOMERY STREET, SAN FRANISCO.

AGENTS FOR

SUNBEAM INCANDESCENT LAMP

Nature smiles through sunbeams."

THE GAMEWELL FIRE ALARM TELEGRAPH CO.

Manufacturers and Contractors

Fire Alarm and Police Signal Telegraphs

Over 600 Plants in actual operation

In principal cities and towns of the United States and Canada. Beware of imitators of our goods. No apparatus made by others can be relied upon to work in harmony with our plants.

Executive Offices :
1 1-2 Barclay St., New York

ONLY AWARD AT THE WORLD'S FAIR

R. A. ROSE,
3 Hardie Place
San Francisco

D. D. WASS

Electrical Engineer

56 FIRST ST., SAN FRANCISCO

Generators and Motors

A FULL LINE OF HARDWARE

—AND—

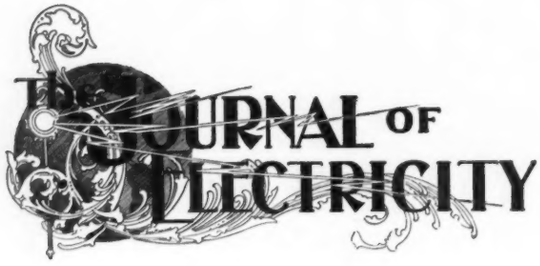
ELECTRICAL SUPPLIES

Electrical Construction and Repairing, General Jobbing, Locksmithing, Etc.

414 LARKIN STREET, - - - SAN FRANCISCO

Telephone "Sutter 1503"

F. W. GOTTERKE FRED. W. LOW



Does Such a Paper Merit Support?

"Its principles seem sound."Scientific Machinist.

"It contains matter exceptionally valuable."—Rambling Notes.

"A publication of the very highest class."—Street Railway Review.

"It has a large amount of local information."—Canadian Engineer.

"Our Golden Gate contemporary is a handhome paper, well edited."—Electrical Journal.

"Neat and attractive in appearance and contains much that is of interest."—Electrical Industries.

"It has received no little attention, and it is with interest that we turn its pages."—Electricity, London.

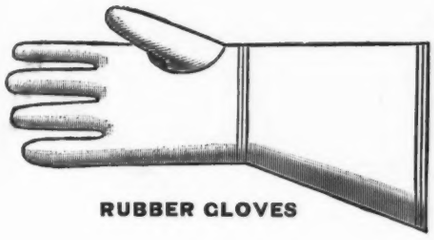
"It contains much valuable knowledge for the student as well as the practical electrician." — Overland Monthly.

"It demonstrates the high stage that electrical engineering and education have reached on the Pacific Slope."—Electrical Engineer.

"It is of handsome appearance and gives promise of being an important factor in the electrical advancement of the Pacific Coast region."—Western Electrician.

Subscription: $1.00 Yearly

Advertising Rates: Moderate



RUBBER GLOVES

Linemen Protect Yourselves

How often do we hear of the death of a lineman, caused by handling a live wire? All this can be averted by the use of rubber gloves. . . . . .

J. W. BROOKS & CO.

San Francisco, Cal.

NEW YORK INSULATED WIRE CO.

SOLE MANUFACTURERS OF

Grimshaw White Core, Raven White Core, Grimshaw Tapes and Splicing Compound, Competition Line Wire, Competition Tape, Lead Covered and Submarine Cables, Bicycle Tape.

WRITE AND GET OUR PRICES BEFORE PURCHASING ELSEWHERE

TRADE MARK. J. R. COLE, Sales Agent 18 SECOND ST., SAN FRANCISCO.

G. E. LAMONT

MANUFACTURER OF

Miniature Lamps

Crookes' Tubes and Glass Apparatus

FOR SCIENTIFIC PURPOSES

No. 15 Thurlow Blk. 126 Kearny Street

SAN FRANCISCO

IMPROVEMENT THE ORDER OF THE AGE.

NEW No. 2

SMITH PREMIER TYPEWRITER

Numbers of important improvements which are found in no other Typewriter.

GREATEST YET PRODUCED.

Write for Illustrated Catalogue.

LEO. E. ALEXANDER & BRO., 218 Sansome Street, S. F.

HAVE YOU,

Mr. Central Station Manager,

Any Additions, Alterations or Repairs to make to your station, or Pole Lines to be built, or other work to be installed, or

HAVE YOU,

Mr. Manufacturers' Agent,

Need for the assistance of a reliable construction concern that will, under contract, relieve you of the installation of plants you sell?

DO YOU,

Mr. Architect, Builder or Owner,

Desire the services of Electricians who will place standard materials and "honest" wiring, **and none other**, in your building or residence?

IF SO,

Our long experience in these lines eminently qualifies us to do it for you cheaper, and perhaps better, than would otherwise be possible.

Unless you want strictly First-Class Work, do not ask us for an estimate.

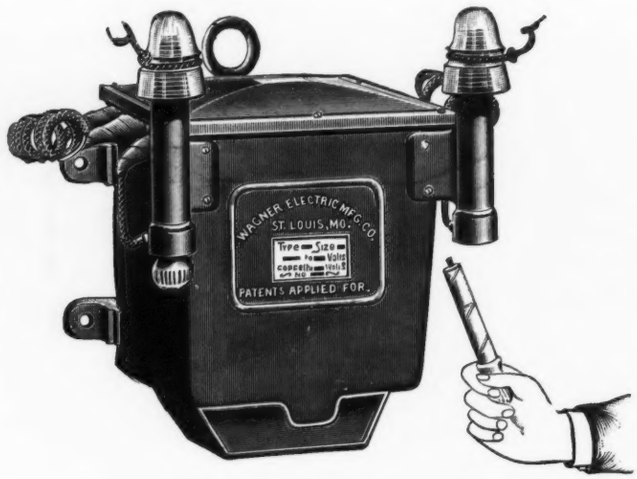
ELECTRICAL CONSTRUCTION & REPAIR COMPANY

232 Montgomery St., San Francisco

WAGNER

Transformers

A NEW TYPE TRANSFORMER PRIMARY CUTOUTS and INSULATOR BRACKETS



☞ Our New Fuse Plugs will not hold an arc with 5,000 volts.

☞ Acknowledged to be of the highest efficiency.

ALL VOLTAGES - - ALL SIZES

Helios Arc Lamps.

THE HELIOS A. C. & D. C. ARC LAMPS

THE ONLY REFLECTOR PLATE ALTERNATING ARC LAMPS

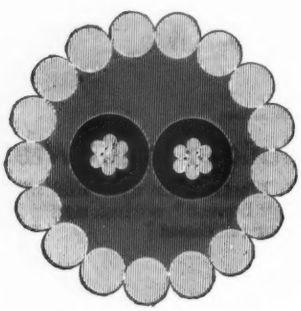
Are those of THE HELIOS ELECTRIC CO., OF PHILADELPHIA, PA., for which is claimed: More Extensive Use than All Other Alternating Lamps Combined; Eighty Per Cent. More Available Light than is Obtained from Any Alternating Arc Lamp; Equal Efficiency with Any Direct Current Arc Lamp Consuming the same Wattage.

SPENCER'S IMPROVED ALTERNATING ARC LAMPS

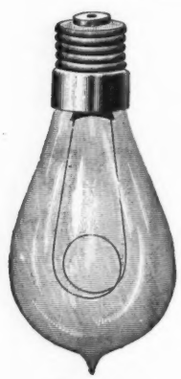
Possess Many Advantages, among which are High Efficiency, Durability and Reliability and Minimum Choke. It starts quickly and can be used successfully at all periodicities.

SPENCER'S DIRECT CURRENT CONSTANT POTENTIAL LAMPS

Are Guaranteed Not to See-Saw.



Rubber Covered WIRE



Buckeye INCANDESCENT LAMPS

Whitney ELECTRICAL INSTRUMENTS

Are Standard the World Over

A LARGE STOCK OF THE ABOVE ALWAYS ON HAND

The Largest General Electrical Supply House on the Pacific Coast

CALIFORNIA ELECTRICAL WORKS

Pacific Coast Agents

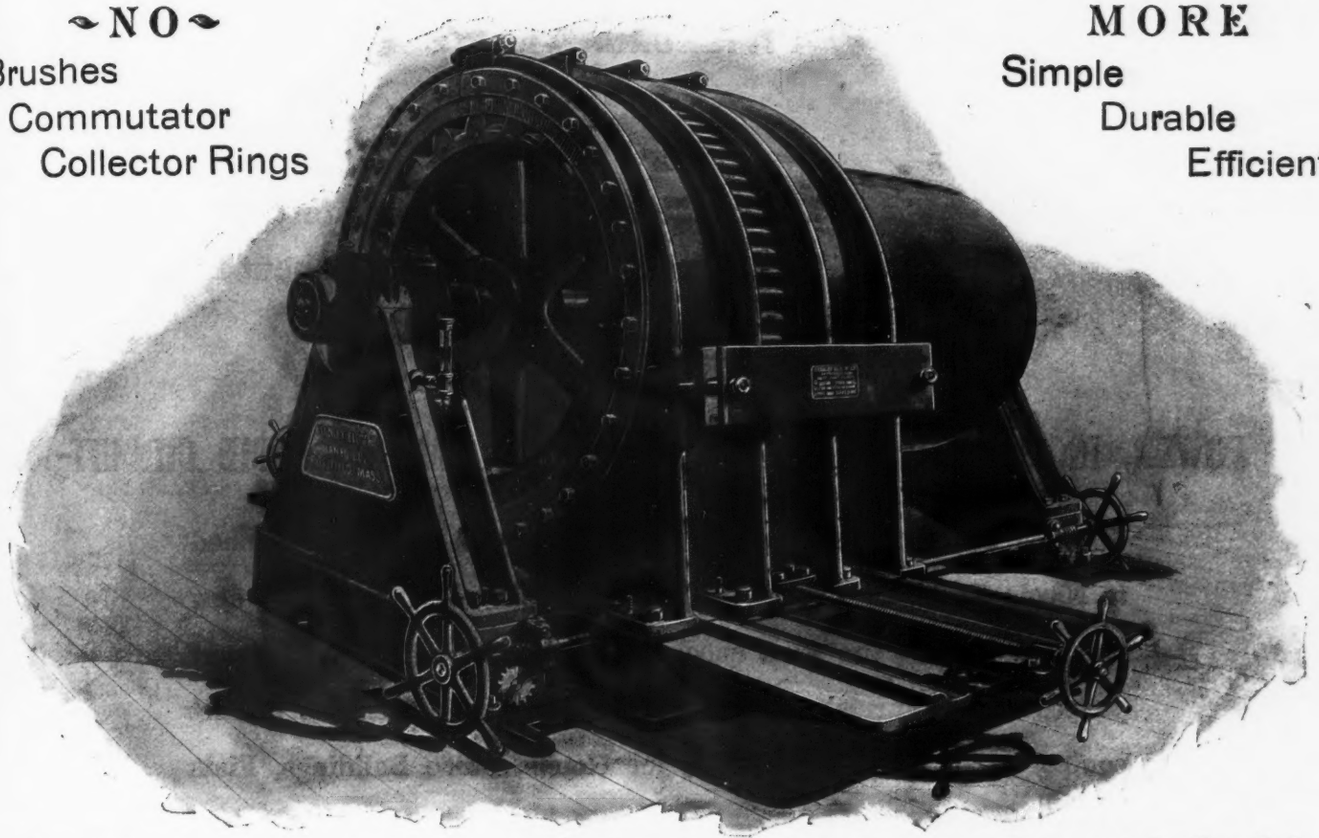
35 MARKET STREET - - San Francisco

THE S. K. C. TWO-PHASE A. C. SYSTEM

NO MOVING WIRE

NO
Brushes
Commutator
Collector Rings

MORE
Simple
Durable
Efficient



The First and Only Complete and Perfected System by which Light and Power can be Supplied from the Same Generator and Circuits. Power Transmission and Distribution made Practical and Commercially Successful.

POINTS OF SUPERIORITY:

Our system is much more simple and consequently much more durable than any other, either direct or alternating.

Our generator is much more efficient than any other alternator, requires less attention and absolutely no supplies except lubricant for bearings.

It is practically self-regulating without the loss of energy involved by compounding or compensating. Other multi-phase machinery require a balance of load.

We have entirely eliminated from our generators the usual sources of trouble, expense and interruption of service: *i. e.*, the revolving armature, commutator, collector rings, brushes, etc.

They can be built for any voltage from 110 for isolating lighting to the high voltages required for power transmission work; in latter case doing away with the expense and loss of step-up transformers; the usual central station machine can be connected at will for either 1,000 or 2,000 volts.

The motors excel in simplicity of construction; in starting torque and simplicity of starting device; in efficiency in the manner in which they take current in proportion to their load, and in uniformity of speed under different conditions of load.

Our transformers insure satisfactory service and the greatest economy. We are prepared to fill all orders promptly.

JNO. MARTIN, PACIFIC COAST AGENT, **106 MARKET STREET, San Francisco.**

STANLEY ELECTRIC M'F'G CO. **PITTSFIELD, MASS.**

Westinghouse Electric and Manufacturing Co.

PITTSBURG, PA.

— — —

The Largest and Most Completely Equipped Electrical Manufacturing Establishment in the World.

— — —

POWER, INCANDESCENT and ARC LIGHTING FROM THE SAME CIRCUIT

We have purchased and are the **sole owners** of the patents issued to Nicola Tesla for the **Polyphase Alternating System,** now recognized to be the most successful system for lighting and power purposes. We furnish complete lines of apparatus for the perfect equipment of **isolated plants** for Hotels, Office Buildings, Flats and Factories.

— — —

Standard Systems

For distribution of lights and power in Large Manufacturing Establishments, Mills and Mines.

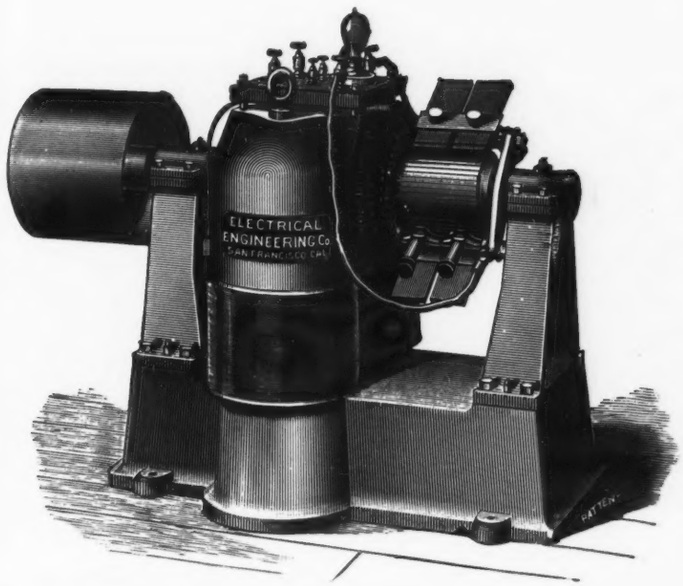
Westinghouse Electric Railway System,

The Most Durable, Economical and Efficient on the market.

— — —

NEW YORK, 120 Broadway
BOSTON, Exchange Building
CHICAGO, New York Life Building
TACOMA, Wash., 102 S. 10th Street
PITTSBURG, Westinghouse Building
BUFFALO, Erie County Building
PHILADELPHIA, Girard Building
ST. LOUIS, American Central Bldg
CHARLOTTE, N. C., 36-38 College Street
SYRACUSE, N. Y., Bastable Building
WASHINGTON, D. C., 1333 F. St. N.
SAN FRANCISCO, Mills Building

For CANADA, address: **AHEARN & SOPER, Ottawa, Canada.**



ELECTRICAL ENGINEERING CO.

Manufacturers of

DYNAMOS AND ELECTRIC MOTORS

FOR THE TRANSMISSION AND DISTRIBUTION OF POWER

Electric Power Apparatus for Quartz Mills Hoisting, Pumping, Drilling and all Mining Work where long distance transmisssion is required, a specialty

OFFICE AND WORKS:
34 and 36 Main St., San Francisco, Cal.

TYPEWRITING MACHINES OF ALL MAKES

Bought, Sold, Rented, Exchanged or Repaired

Typewriting Supplies of all descriptions

S. F. TYPEWRITING EXCHANGE
TELEPHONE 550. 310 CALIFORNIA ST., S. F.

FERRÉ ELASTIC PAINT

Insulating. Odorless. Quick Dryer and Preservative. Water Proof. Rust Proof. Acid Proof.

Send for Sample.

A. Grothwell
15 Halleck St. San Francisco

H. W. JOHNS MANUFACTURING CO.

87 MAIDEN LANE, NEW YORK.

MANUFACTURERS AND DEALERS IN

Asbestos and Molded Mica Goods

PAINTS, COLORS, Etc.

H. W. JOHNS' Liquid Paints; Roof and Railway Paints; Fire-Proof Paints; Liquid Coach Colors; Colors in Oil; Shingle and Wood Stains.

ROOFING AND FIRE-PROOF CONSTRUCTION MATERIAL

Asbestos Roofing; Roof Coatings and Cements; Asbestos Building Felt; Asbestos Superator; Asbestos Water Proof Sheating.

STEAM PACKINGS.

Asbestos Rope Packing; Asbestos Wick Packing; Asbestos Sheet Packing; Vulcanized Rope Packing; Asbestos and Rubber Cloth, Tape, Gaskets, Etc.

ASBESTOS FABRICS, Etc.

Asbestos Cloths for Theatre Curtains, Etc.; Fire-Proof Rope for Fire-Escapes, Etc.; Fire-Proof Cords, Twine, Rugs, Mats, Screens, Etc.

FIRE-PROOF CEMENTS AND COATINGS

Asbestos Furnace Cement; Asbestos Retort Cement; Plastic Stove Lining; Concrete Coating, Etc.

INSULATIONS.

VULCABESTON: Controller Parts, Field Spools, Bushings, Etc.

MOULDED MICA: Trolley Line Insulators, Weather-Proof Sockets, Etc.

H. W. JOHNS MANUFACTURING CO.

Represented by CHAS. M. MAXWELL

44 Fremont Street, San Francisco.

AND

APPARATUS

FOR LIGHT

AND POWER

MANUFACTURED BY THE

FORT WAYNE ELECTRIC CORPORATION,

FORT WAYNE, IND.

Pacific Coast Office and Salesroom

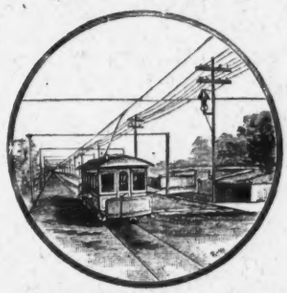
18 SECOND STREET, San Francisco.

Washburn & Moen Mfg. Co.

DRAWERS OF

IRON, STEEL and

COPPER WIRE



MANUFACTURERS OF

BARE and INSULATED

ELECTRICAL WIRES

BARBED
BALING
COPPER
INSULATED

WIRE

NAILS
ROPE
SPRINGS
BALE TIES

WORKS: WORCESTER, MASS.; WAUKEGAN, ILL.; SAN FRANCISCO, CAL.

SAN FRANCISCO OFFICE:

8 AND 10 PINE STREET

FRANK L. BROWN

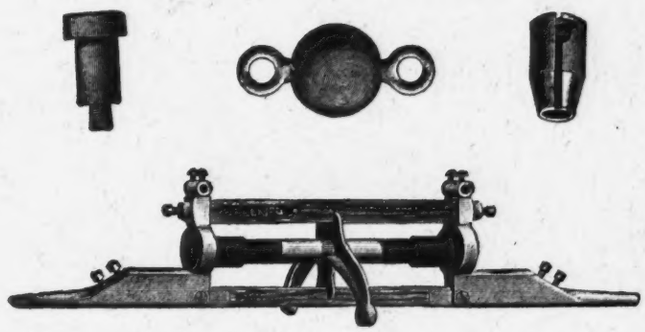
PACIFIC COAST AGENT

REGER & ATWATER

ELECTRIC RAILWAY SUPPLIES

214 Pine Street, San Francisco, Cal.

Straight Line Insulators
Curve Insulators
Trolleys
Switches
Cross Overs
Turn Outs
Pole Brackets
Pole Ratchets
Strain Clamps
Magnet Wire
Feeder Wire
Trolley Wire
Guard Wire
Span Wire
New Haven Car Registers



Steel Gears and Pinions
Trolley Cord
Trolley Harps
Trolley Bases
Trolley Wheels
Trolley Springs
Graphite Bushings
Bearings
Feeder Ears
Solder Ears
Clamp Ears
Porcelain Knobs
Porcelain Cleats
Electric Packing
Bemis Car Trucks

Dropped Forged Commutator Bars • East India and Amber Mica Segments

PACIFIC COAST AGENTS FOR

THE OHIO BRASS CO.

Manufacturers of Electric Railway Supplies

WRITE FOR CATALOGUE No. 3.

MANSFIELD, OHIO